The Blast Furnace and Steel Plant

By--Product Plant at Sheet & Tube Works

New By-Product Coke Plant of the Youngstown Sheet & Tube Company, Recently Completed, Contains Many Means for Expediting Materials Handling, With Dual Units.

By **CHARLES C. LYNDE.**

Concentration and consolidation of all the units and departments contributing to the manufacture of finished steel products led the Youngstown Sheet & Tube Company to the installation of its own coking plant, for the furnishing of fuel for the six blast furnaces comprising its raw material department. This coke plant, specially designed to give economy of manufacture and reliability of operation, at present consists of four batteries of Koppers ovens, each battery being composed of fifty-one ovens, of 12½ tons nominal capacity. The coke plant is built as an extension of the former main plant of the Sheet & Tube Company down the river below Youngstown, and is close enough to the plant to give all haulage within the company's jurisdiction. The ovens are located across the river from the furnaces, but a special coke bridge gives uninterrupted handling of the fuel for the stacks. Complete provision for the arresting of all by-products is made in the Semet-Solvay benzol plant, which in itself recovers benzol, toluol and naphtha from the coke oven gas stream after it passes through the Koppers direct process tar and ammonia

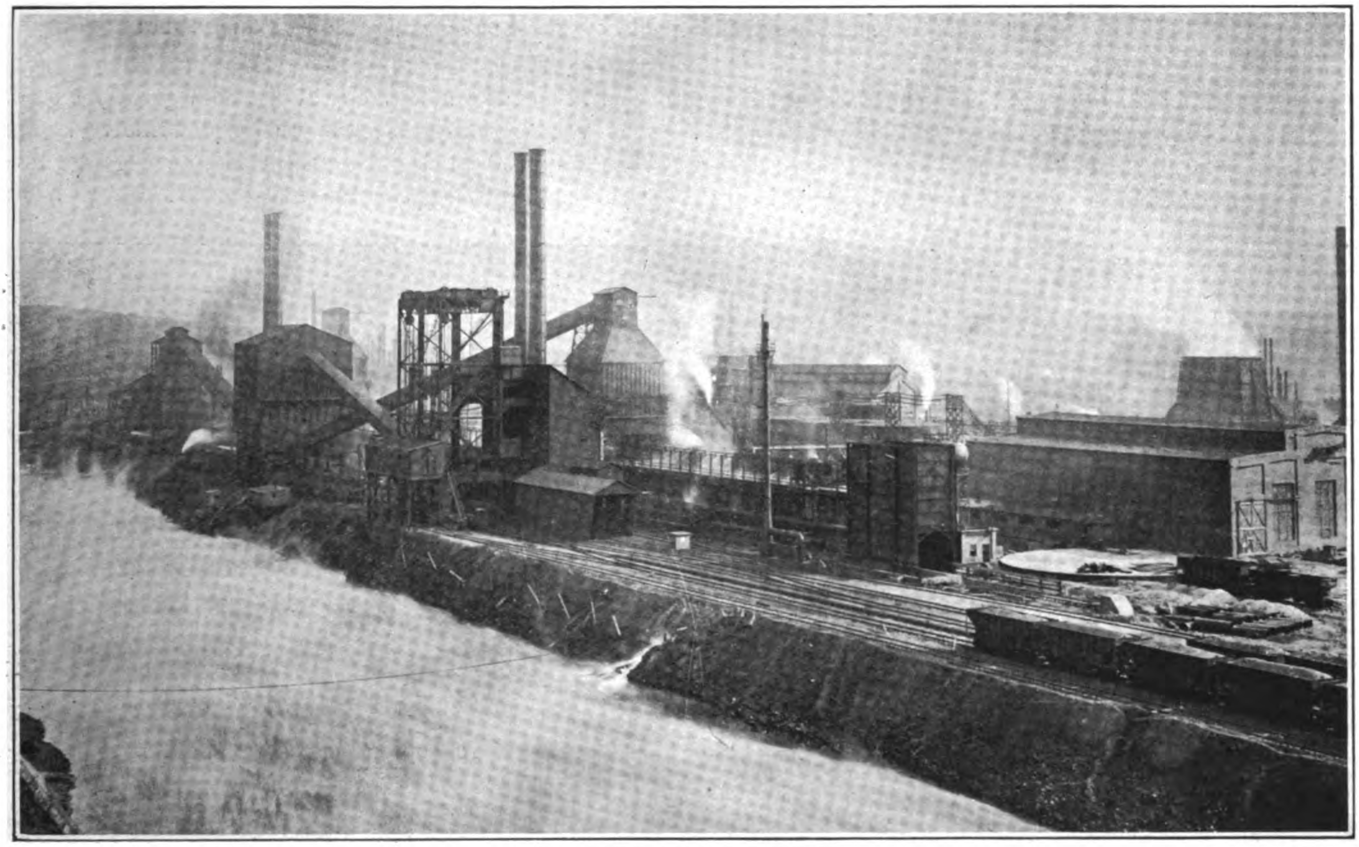

Figure 1.—The coke plant from across the river, one quenching station in the central foreground and the dumper and storage buildings toward the left.

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recovery plant. The plant as now being operated is making slightly in excess of 2,300 tons of coke per twenty-four hour day, which leaves a small margin over normal furnace demands for the four stacks at the main plant.

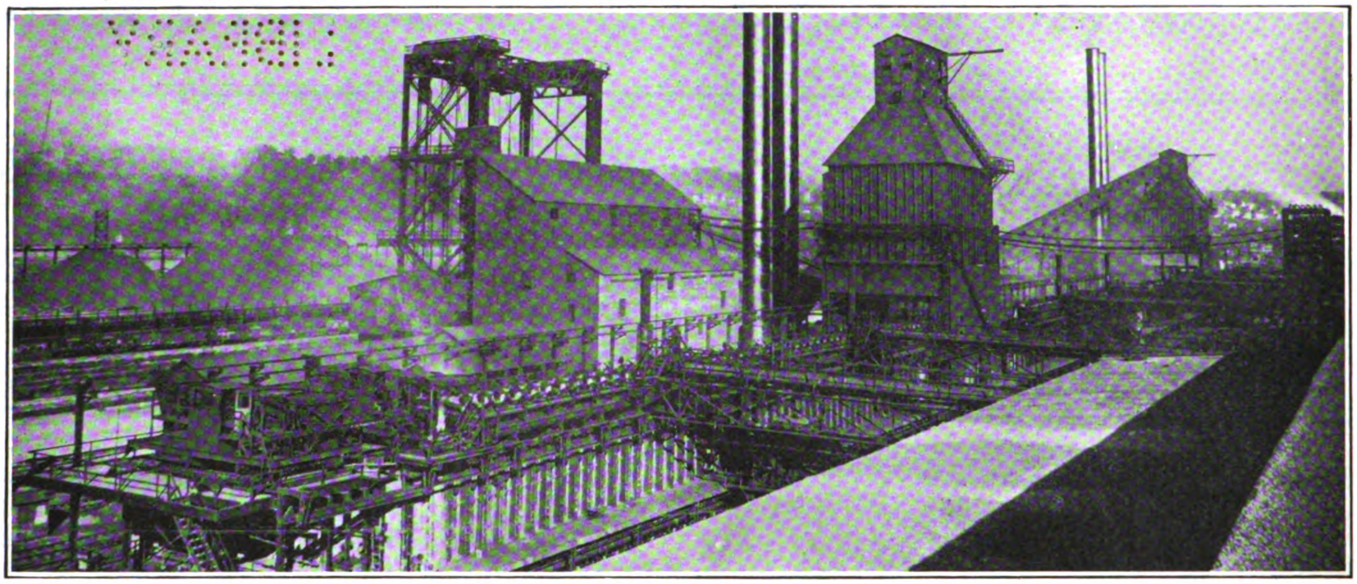

Figure 2.—Top of dumper and crusher building with storage bins in center, showing dual layout.

Rail haulage, formerly relied upon to provide a steady stream of coke for the furnaces, now is utilized to bring in the raw coals from the different mines. As the cars come in they are sorted on a coal analysis basis onto various storage tracks, and held there awaiting time for them to be unloaded by the high-lift car dumper which normally handles all incoming coal.

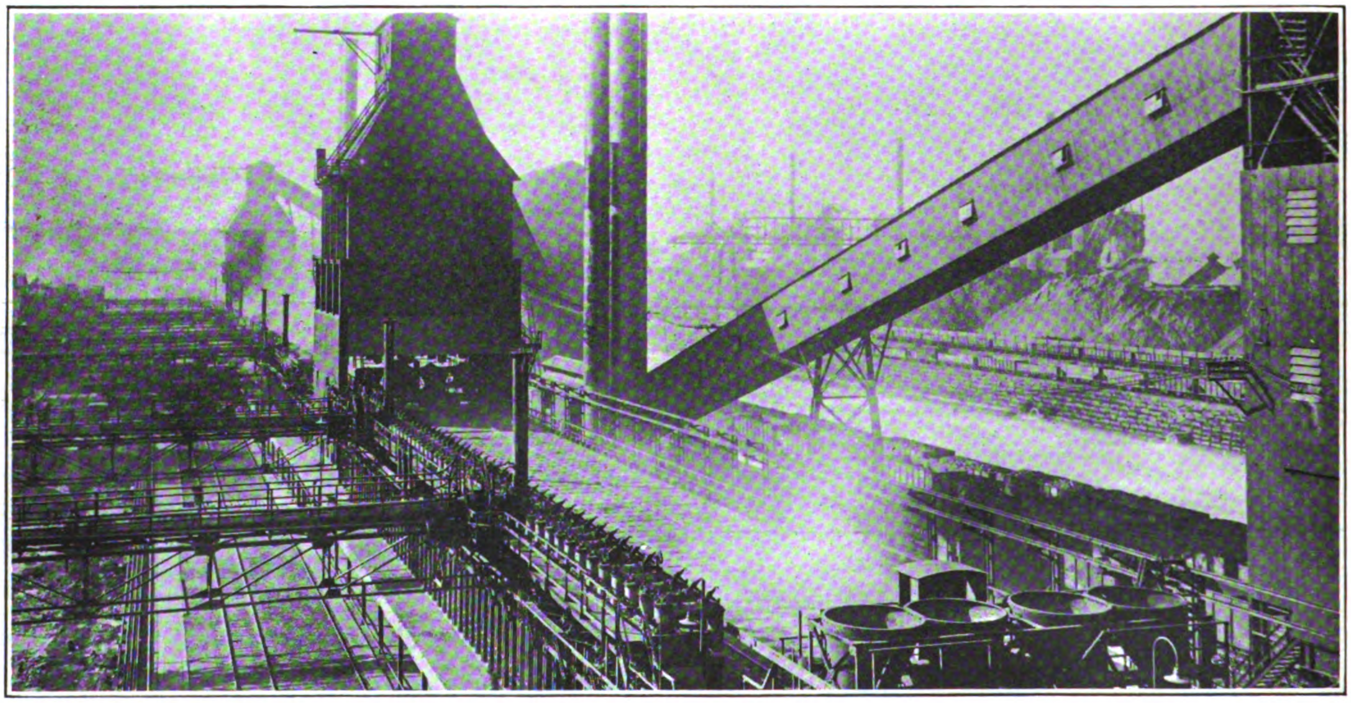

Figure 3.—Looking down on battery, with oven larry in foreground, showing shape of charging hoppers which prevents clogging.

By giving the raw coal one high lift at unloading, much preliminary lifting by a conveyor is done away with, and the movement of the coal greatly expedited. A Westinghouse electric pusher locomotive, running on a special track between the standard gauge lines in the coal storage yard, moves the cars to and from the unloader track, and spots the cars for lifting. This locomotive is provided with pushers on each side, and in this way controls all the tracks within its yard. It is also provided with cable and drums so that it can be used to bring cars in from outside of its current radius as limited by the covered third rail system.

The car dumper is provided with two dumping stations, one for regular operation, and the second for storage purposes. Under normal routine, the car is hoisted to the high position, and there dumped at a height sufficient to permit the coal to move through gravity to the breaker and hammer mills, eliminating the need for belts usually found here. Frozen coal is partially thawed on the ground before dumping, by fires ranged along each side of the waiting track, and the smaller lumps of frozen coal treated as mine lumps in the subsequent handling.

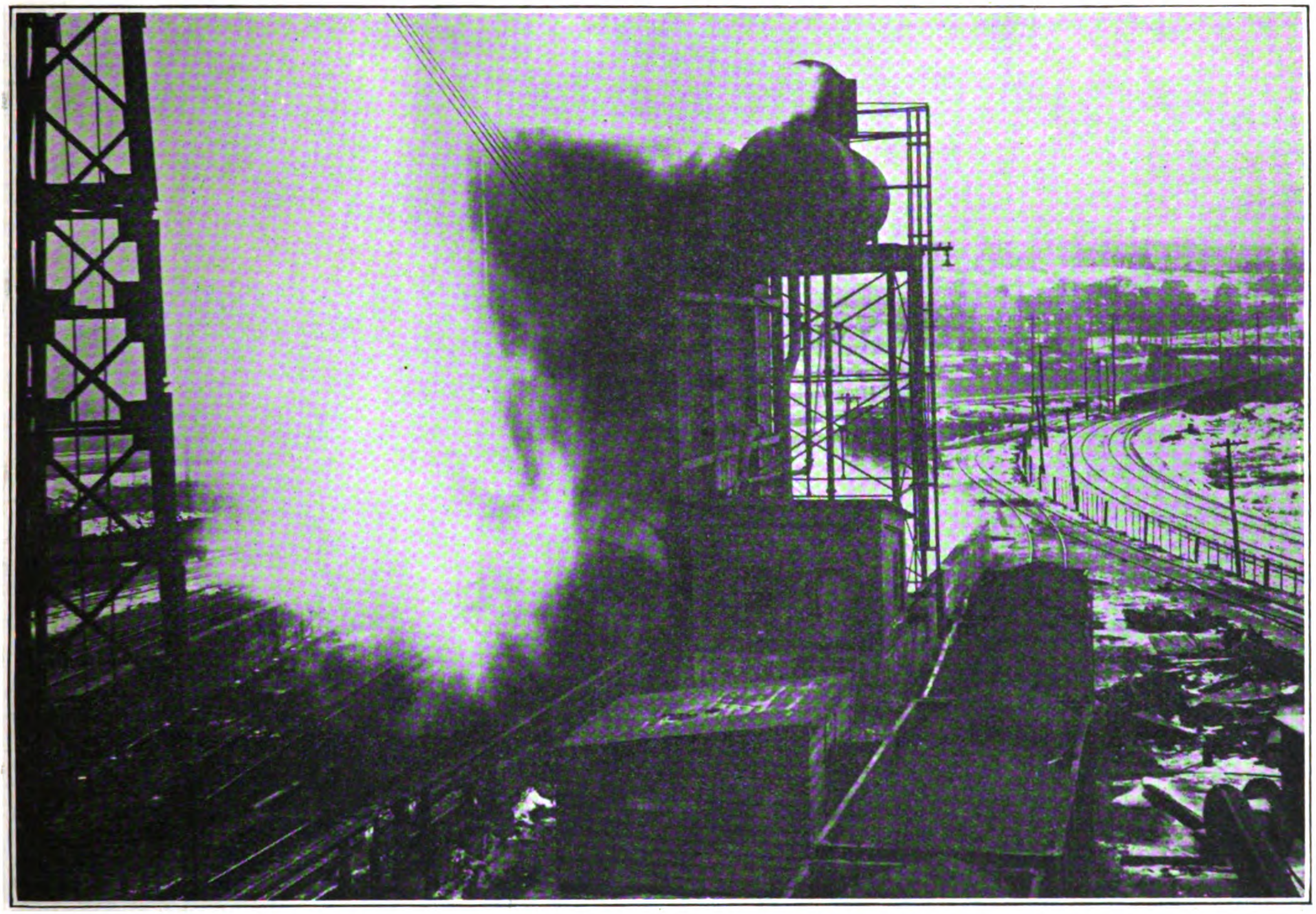

Figure 4.—One of the quenching stations in operation. The side walls serve as a stack, and carry most of the steam up and away from the quenching-car operator.

The lower position of the car dumper is for transferring the coal into a 110-ton electric side-dump transfer car to store the coal within the radius of action of a grab-bucket equipped bridge which will be installed to provide for fuel storage in excess of that now obtainable through loaded cars, standing in the yard. This storage coal will be rehandled into railroad cars by the bridge, as needed, and then taken by the car to the dumper, and elevated to the higher position before dumping.

The coal breaker building is fed by the discharge from the dumper, the coal being stored in the meantime in a storage and receiving hopper. From the hopper the coal passes to the flight feeder serving the breakers. Feed from this bin is by gravity, and is controlled by the demand of the system farther along. The receiving hopper is fitted with a grating of beams, with eighteen-inch apertures, to prevent clogging of the outlet through the admission of large lumps of frozen coal.

Coal is first screened and divided, the fine passing to the hammer mills and the coarse to the breakers. In this latter equipment, provision is made for sorting refuse from the coal as discharged by the breakers. This refuse is fed onto a sorting conveyor belt, from which sorters pick the iron and slate, allowing the unsized coal to pass to the breakers.

Spare units are provided in the breaker equipment and hammer mills so that provision against shutdown through a breakdown is secured. Two hammer mills are kept as stand-by, and may be instantly put into service should they be needed. Hammer mill motors and other electrical equipment are housed in a special compartment which is sealed tightly against the mills themselves to eliminate the danger of dust explosions.

The oven batteries are operated as two sets of

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two each, one set of equipment serving 102 ovens. The quenching cars are filled at their respective ovens, run to the end of their set and are quenched, and then return to a coke wharf at the middle of the oven installation, where both unload on the same wharf at one time.

Work on both sides of the oven at drawing time has been systematized and improved by the use of a complete electrical signalling system, so that premature pushes are practically impossible. The coke side doors are extracted by a special design Koppers extractor, mounted on a truck which runs the entire length of the four batteries. Three of these machines are provided, one being kept in reserve for emergency use. The extractor and quenching car travel together, so that each has its round of work on an oven to complete within the five to six minute interval between ovens. When the door machine operator on the coke side of the ovens sees that the guide is placed and the coke ready to push, he merely signals the pusher operator by means of the electrical signaling system, and the coke is drawn in safety.

On the pusher side of the ovens the doors are handled by the pusher itself, special equipment being provided for removing the door of the oven to be discharged. In practice on this set, it is customary to combine operations in many instances by removing one door of one oven while the leveler is smoothing down the coal just deposited in an adjacent oven.

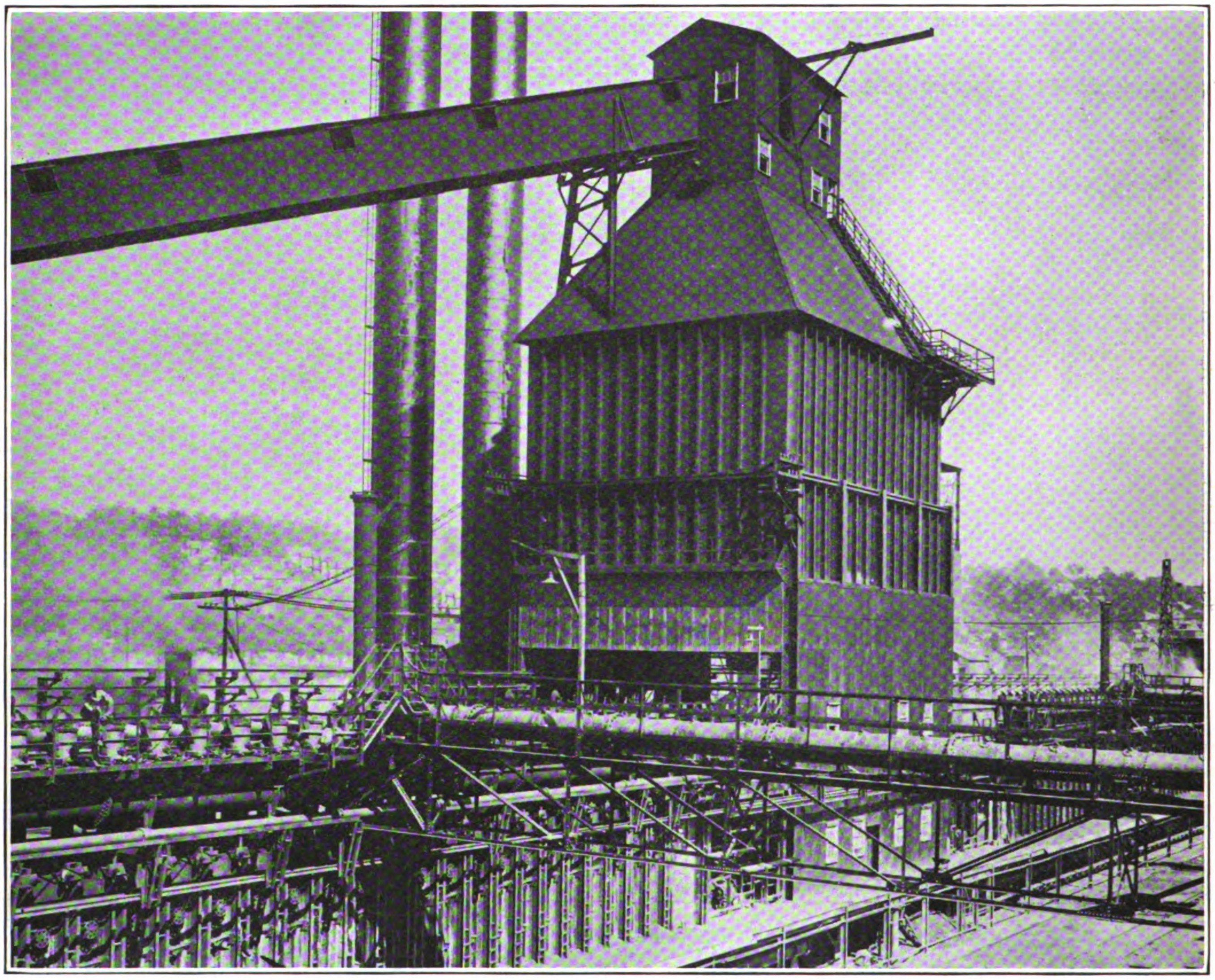

Figure 3.—One of the two coal bins straddling the ovens and serving the larry cars.

Coal for charging is stored in bins straddling the batteries, it being properly proportioned to give the desired grade of coke before reaching this point. Mixing is done in the mixing house, which is provided with four 550-ton bins, over which the belt conveyor from the hammer mill screens discharges, a pivoted discharge enabling the operator to discharge the coal into the desired bin. These compartments are glass lined on the bottom, and discharge through a graduated gate, with screw adjustment, so that the flow of different kinds of coal to the mixing belt can be carefully regulated.

Larries are weighed with their load as they take

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it on from the discharge chutes of the bins, so that the exact amount required for an oven is weighed out onto the car as it is filled. The hoppers on the larries are built cone-shaped, with one edge or side perpendicular, as it has been found that this plan will prevent the coal clogging or packing unduly. This form of hopper most nearly resembles the opening left in any coal bin with a bottom outlet.

Hot water for the quenching stations is taken from the efflux of the primary gas coolers, and stored in the tank shown at the right of the station illustrated. The water is released for quenching the coke by a valve convenient to the quenching car operator. After cooling the coke the water flows through a screen in the base of the station, where all coke that has been washed from the car is collected, and thence out into the river nearby. A locomotive crane and grab bucket are used to remove the coke from the dump under the station.

At the coke wharf the coke is controlled by a rank of finger gates, each about six feet wide. These gates are operated by extension levers, and are controlled from a platform running the length of the wharf.

Rotary feeders at the bottom of the wharf take the coke as it passes under the finger gates, and pass the charge to the conveyor. As each section of the wharf is cleared the finger gate is lowered and provision thus made for the next charge of coke, which will be, in normal times, on the wharf within six minutes from the time the last was deposited. By the sectional handling of the coke in this way it is possible for one man to quench the hot spots properly, and at the same time prevent over-quenching charges.

Coke from the wharf is discharged by the offtake conveyor into a grizzly screen in the coke crusher house. Oversize coke is automatically sorted out and fed to a crusher. The entire product then passes onto a second conveyor, and is then screened and the breeze removed.

Blast furnace coke from the second grizzly serving as final screen is received in a curved chute, so shaped as to give a minimum of coke breakage. These movable curved chutes discharge the coke into three bins, whence it is passed into the transfer car.

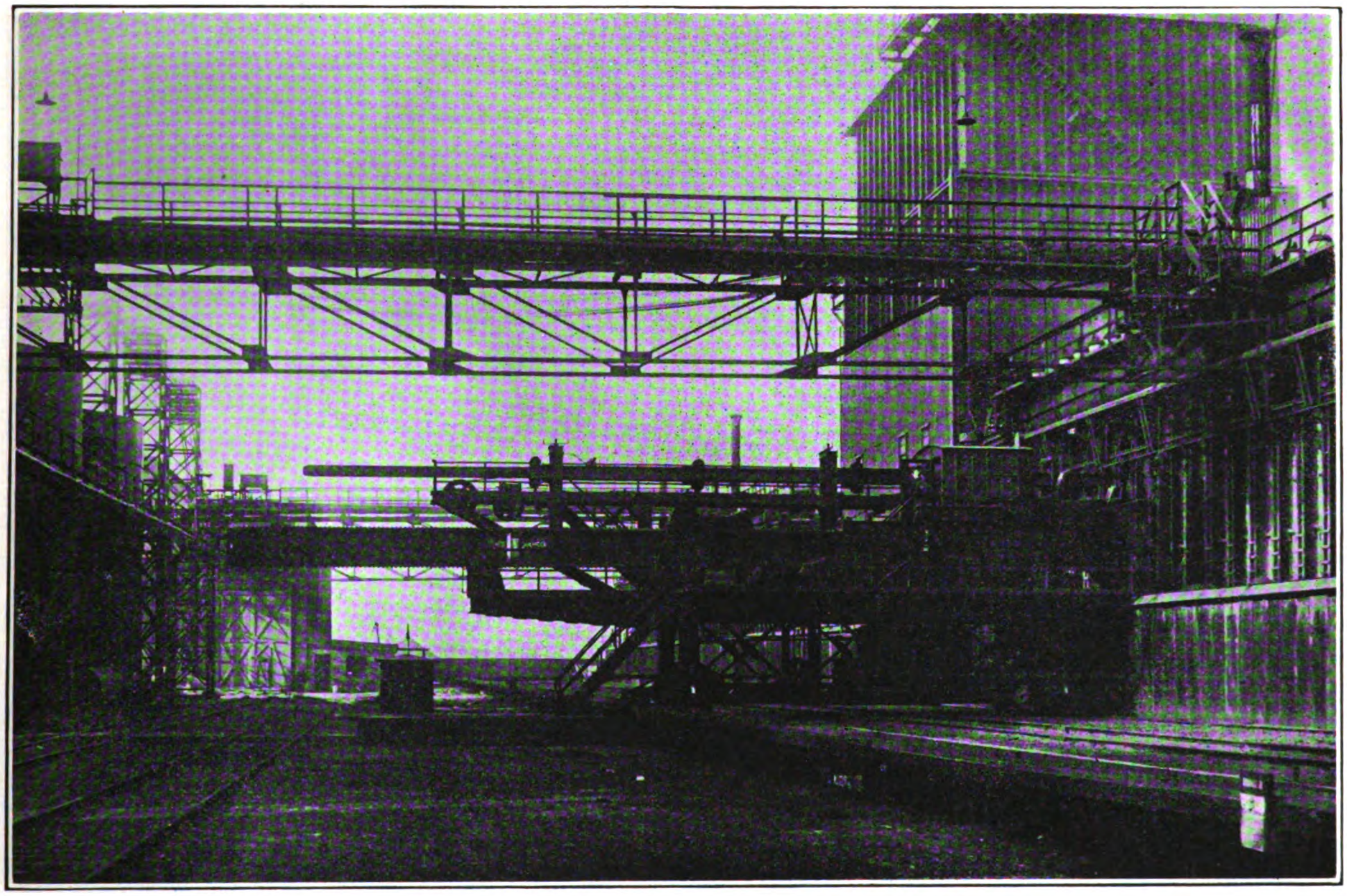

Figure 6.—Pusher at battery 3, showing thorough guarding of moving parts.

From the final screening the coke is carried by electrically-driven transfer cars directly to the coke storage points for the four blast furnaces across the river from the coke plant, so that there is normally no store of furnace coke on the by-product side of the river.

The small coke falling through the separating grizzly is further divided by an additional screening into domestic coke and breeze. This latter product is used for fuel under plant boilers and elsewhere that heating or power for steam drives is needed.

There is no point in the entire plant where the failure of some one unit will tie up production for more than the time required to retire the disabled unit and substitute one in perfect working order. If the coal dumper, for instance, should fail, track hoppers and a bucket elevator would enable the plant to continue taking in coal at the rate of 250 tons per hour, which would more than cover the running needs of the blast furnaces, even on full production. The same duplication of units is found through all motive units on the ovens. There are extra charging larries, extra pushers, an extra quenching unit, and other doubled equipment to provide against shutdown. In case of trouble to the trestle providing for coke haulage across the river to the blast furnaces, depressed tracks are built in at both quenching stations so that all the coke handling from quenching through wharf and screens can be eliminated and unsorted coke for pressing furnace needs handled by the regular railroad lines and steam locomotive haulage to the coke bins of the blast furnace plant.

Safety to the workmen is considered first at every turn in the plant. All elevated platforms and walkways are provided with guard rails and tee boards, and every precaution taken to safeguard not only those who work on these positions, but also those whose work takes them below these places, and who therefore are exposed to the danger of dropping tools and other articles.

At regular intervals along both sides of the oven batteries are conspicuous danger signals warning of the presence of electricity in the covered third rails, and all overhead transmission lines are blazoned with the company's danger signs.

One of the shafts of the drive gear on the pushers is equipped with two couplings carrying short lengths of chain, which fly out by centrifugal action as the shaft revolves and strike two steel disks rigidly supported within reach of the chain ends. These gongs have a distinctive note and give unmistakable evidence of the approach of the pusher, even above the other noises incident to the plant and the extraneous disturbances coming from passing switch engines and other rail traffic.

The structural work on batteries number one and four is left in such condition that extensions may be built on at any time and the coking capacity thus enlarged. This move would be more than covered by the present equipment for handling and preparing the coal, as the installed capacity is considerably more than the present coking capacity of the by-product ovens.

Room is afforded on the ends of both batteries to permit of the addition of extra ovens, with the moving of practically no equipment, and the laying of the necessary foundations. The location of the coke wharf at the center of the battery lay-out insures the transportation of the coke at all times, even though it were found desirable to add to both ends of the existing string of ovens.

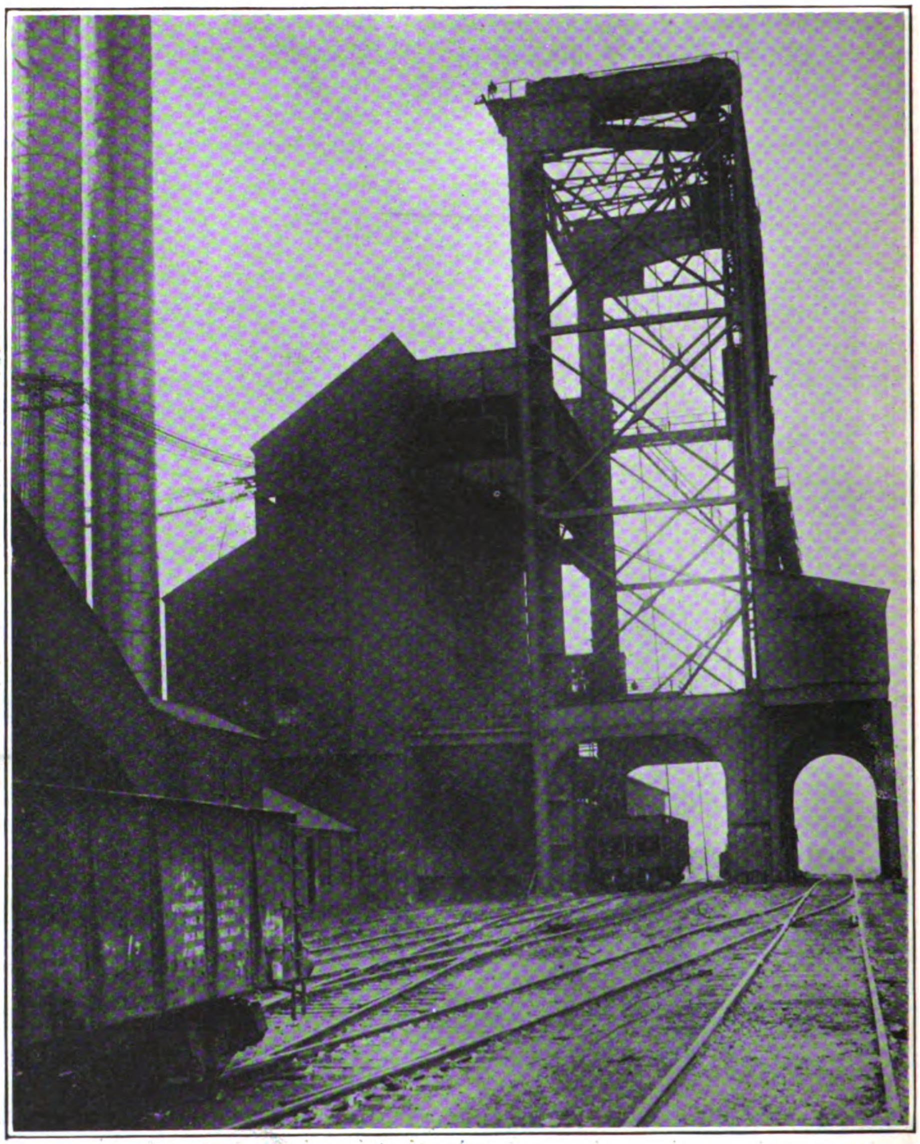

Figure 7.—High-lift dumper with car in position for hoisting.

The addition of the projected coal storage space and equipment will further tend to insure the plant against the traffic tie-ups which are to-day cutting such a figure in production schedules, as there will then be available sufficient stocks of raw materials to enable the entire plant to run at regular schedule for some time without any incoming shipments.

Design of Mill Rolling Flat-flanged Beams

Continuing a Discussion of the Types and Variations in Mill Design to Give Economical Rolling of Special Beam Shapes. Reasons for Certain Mill Failures.

By **F. DENK.**

III.—REVERSING UNIVERSAL MILLS.

When an **I** or **H** beam is supposed to be rolled in a universal mill the section has to be broken down first in a roughing blooming mill (see Fig. 8 in the December issue); this, at least in the largest number of cases, is true where universal mills are applied for the purpose in question. This mode of rolling, however, introduces a new difficulty in regard to the working inasmuch as in the roughing rolls the web is worked upon more than are the flanges. In order to equalize this difference, the rolls in the universal mills have to be set and reset to different distances, i.e., the mills of such type should be designed in such a way that it is possible to move the vertical rolls independent not only from the horizontal ones but also from each other. But this is very difficult to accomplish and, for this reason, the setting of the different rolls was dispensed with and instead of one or two universal stands several of these stands were erected with fixed grooves in each one. Thus the main advantage of a universal mill—that one stand can be used for the rolling of different sections—was given up, and the universal mill changed practically over into a continuous mill, without doing away with some of the other difficulties which will be encountered when it is tried to roll a complicated section, as an **H** beam certainly is. Besides avoiding undue, or even dangerous, internal stresses, besides preventing the formation of fins and the eccentricity of the web, care must be taken to make web and flanges comparatively thin, in order to enable the manufacturer to roll the beam cheaply enough so that it can compete economically with built-up beams. In how far these points have been met and overcome in the construction and design of universal mills for manufacturing **H** sections may be seen from the following.

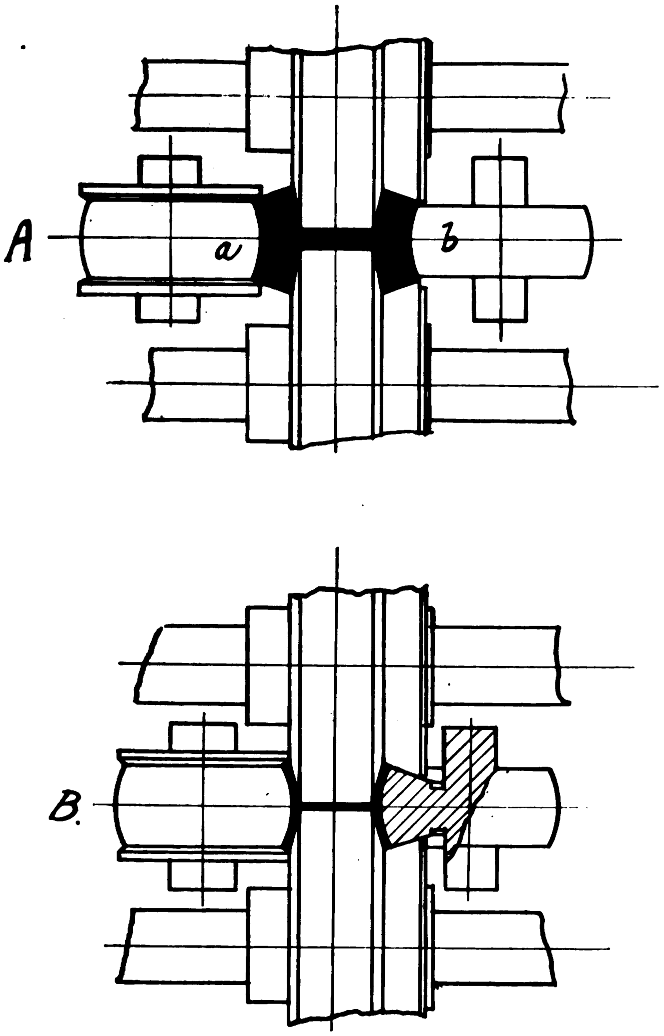

Figure 9.

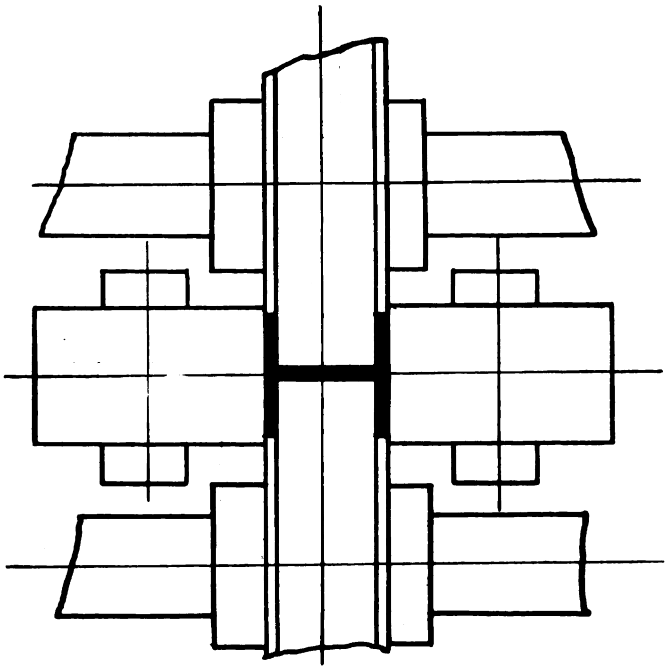

Figure 10.

In 1887, H. Sack in Germany patented a universal mill for rolling **H** beams with parallel faced flanges. The mill consisted of one set of rough rolls and two universal stands. (Since a roughing mill is connected with everyone of the universal mills described here except where stated to the contrary, it may be sufficient to refer to Fig. 8, which shows a typical set of rolls for the preliminary rolling of an **H** beam).

The first stand of the Sack mill contained four rolls all lying in the same vertical plane. The two horizontal rolls were equal to each other, but unsymmetrical among themselves, while the two vertical rolls were symmetrical among themselves, but unequal to each other (see Fig. 9, A). After having broken down in the blooming mill to a rough **H** shape, the beam entered the first stand and was rolled there to the final size, but with the flanges bent outward (see Fig. 9, B). To do this, the rolls had to be adjusted after each pass and besides the beam had to be turned 180 deg. ofter each pass. This turning of the beam around 180 deg. was claimed by Sack as being not a disadvantage, as long as it could be done without losing any time and without the necessity of employing extra men for doing it. Besides, he said that the amount of extra work and power necessary to operate the tilting gears was immaterial. This extra work and power, he claimed, had been reduced to a minimum by the arrangement that one lever was sufficient to operate the two manipulators one of which was located in the front and the other in the back of the stand. This lever, in turn, was placed on the operating pulpit together with the other levers which are required for the running of a universal reversing mill and thus the employment of extra men for its operation was avoided. The manipulators or tilting gears, however, are complications in themselves and notwithstanding the claims made by Sack are apt to require considerable time for their operation, especially when the beam is long and bent. This difficulty is increased by the unsymmetrical section developed at each pass. Since the one side of the beam is rolled in a practically open groove (Fig. 9, A,a) and the other side in a closed groove (Fig. 9, A b), an unsymmetrical section must be developed, which, naturally, will disappear towards the end of the rolling process, because then both sides will be rolled in closed grooves. (Fig. 9, B). This unsymmetrical section has the tendency to bend the beam sideways and, for this reason,

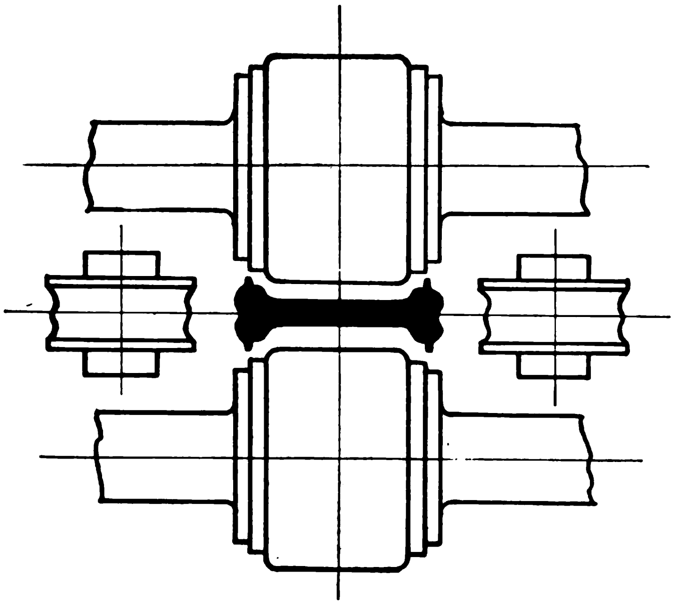

Figure 11.

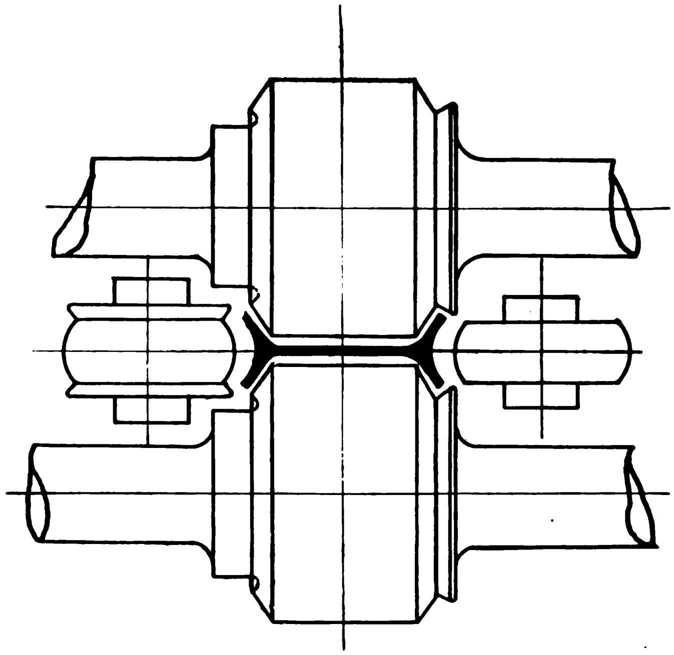

Figure 12.

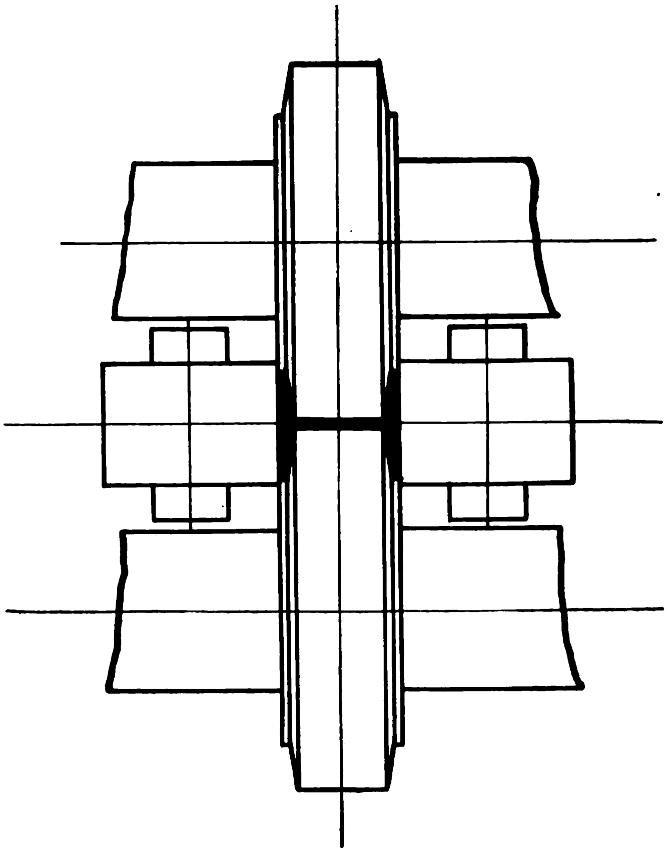

Figure 13.

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Characteristic Edges of Pig Iron Samples

The Practical Furnaceman's Method of Judging the Iron Analysis at Cast Time—Relation the Iron Has to Furnace Conditions—Causes Which Give Individuality to Each Test Sample.

By **WALLACE G. IMHOFF.**

Why does the top of the iron sample get a mossy black coat over it? What does it signify in its relation to furnace conditions? Why does the top of one sample rise in humps? What causes the holes in the top of another? Why is still another so smooth on top and what is the reason for the presence of the little worm or curl on still another? There is a definite cause for the hump in the back of one sample; the holes and pits in still another have a reason for their existence, and the blisters on another have not gotten there by chance.

A close study of all conditions under which each kind of iron is made will reveal some very interesting facts as to why each type of iron has its own peculiarities. The various kinds of slag all leave their mark on the iron and the furnace conditions in each case determine the character of the slag. It is a very difficult problem to try to solve the cause of all these peculiarities at once but when taken one by one they form a most interesting story of what has happened in the furnace during the hours of metallurgical action preceding the cast.

That the furnace conditions and slag effect the physical properties of the iron also may be seen from the following illustration. Given two pigs of exactly the same analyses; the one is soft, has nice open grain and is easily broken; the other is hard, the grain is close, it is brittle and hard to break. What has caused the difference, since they both show the same analysis, and under what conditions were each made? As a definite illustration the analysis of each may be taken to be—silicon 1.50, sulphur—.025.

The conditions under which the first was made were high lime, low fusion zone, and an extremely hot bottom. The lime-sulphur reaction is a high temperature reaction and always takes place with a very high hearth temperature, or in other words on a hot furnace with a low fusion zone. The excess of lime not only keeps the sulphur low but also the silicon. Such conditions favor the separation of the carbon and this in turn softens the iron, open the grain, and makes it easily broken.

The conditions under which the second was made were low lime, high fusion zone, and fairly cold furnace. The high fusion zone causes the lime to react with the silica and let the sulphur be carried off as free sulphur in solution. Such conditions favor keeping most of the carbon in the combined form and this in turn hardens the iron, closes the grain, and makes it hard to break.

There are many peculiarities which make each cast different from the preceding one and it is the object of this paper to offer a plausible explanation for the individuality of each condition. In figure 1.; from left to right, the first four samples show a top which is peculiar to high lime, low fusion zone, and a hot bottom. This iron when running is very hot, very fluid, and just as soon as the sample is poured it chills over quickly and then a mossy, dusty, black coat starts to appear over the top. This top is typical of a very hot, low silicon, low sulphur furnace with heavy lime. The analyses of the iron and cinder for such iron are:

Iron.

Silicon	1.42
Sulphur	.030
Phos.	.52
Mn.	.96

Cinder

Silica	30.76
Alumina	13.06
Bases	51.18

In proportion to the silicon content the sulphur is high hence a large part of the carbon in the combined form which has given the iron its fluidity. It will also be seen the grain is fine and that it has a black look due to graphitic carbon. By rubbing the finger over the fracture the black shiny deposite due to graphite can easily be seen. This iron is soft and the mossy black coat which covers it as the samples cools seems to be the separation of very fine particles of carbon.

The middle sample of figure 1. illustrates the top of a typical foundry iron sample. Such on iron and cinder might analize—

Iron.

Silicon	3.54
Sulphur	.014
Phos.	.72
Mn.	.85

Cinder

Silica	32.00
Alumina	14.38
Bases	48.62

The peculiarities of such iron are seen to be the rugged top full of holes. It is plain the conditions under which this iron was made were different from the first four samples. By examining the slag analysis and comparing it with the former we note higher silica, higher alumina, and less bases. The low bases with a hot bottom accounts for the high silicon in the iron, the heat accompanying such iron accounts for the low sulphur. The furnace conditions are low lime, low fusion zone, and hot bottom. The heat accompanied by low lime drives the silicon into the iron and the decrease in silicon leaves the lime to combine with the sulphur.

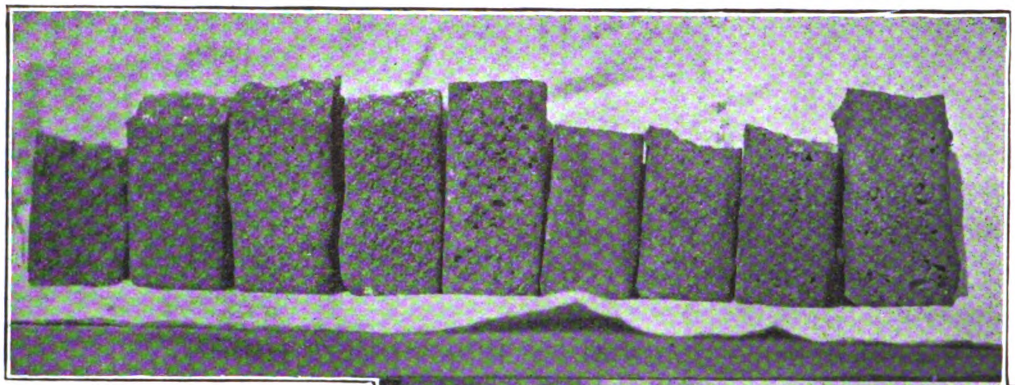

Fig. 1.—Iron samples from various casts showing the peculiarities which can be directly attributed to the condition of the furnace.

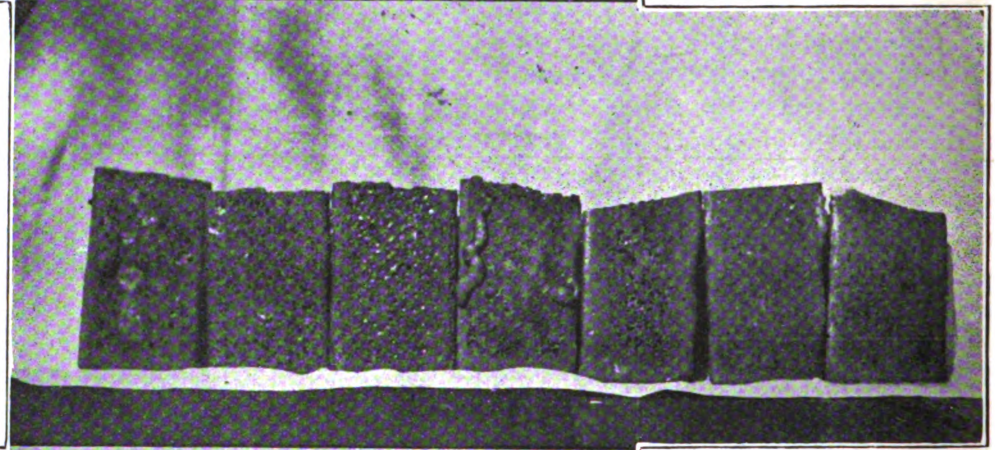

Fig. 2.—Peculiarities in the tops of iron samples due to sulphur and manganese in the iron as cast.

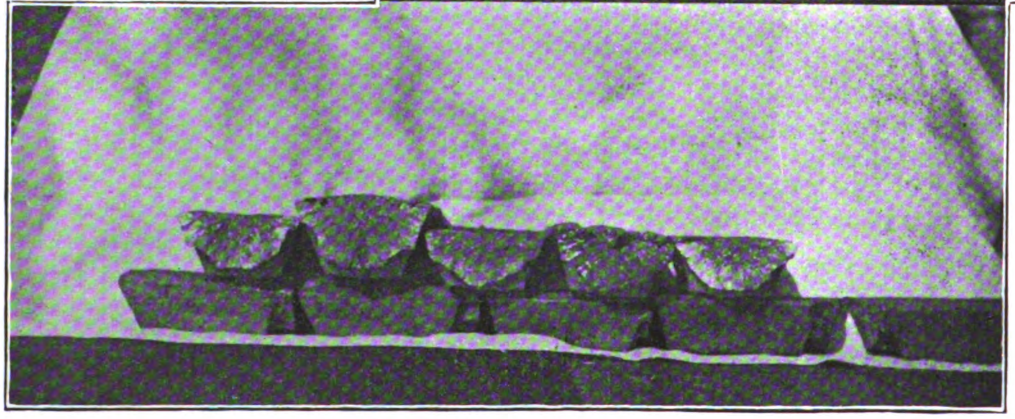

Fig. 3.—Fracture and grain of iron samples due to sulphur. Note the hump on the second sample from the left end.

This iron is very hot thick and mushy and chills up immediately leaving a large skull in the sample dipper. Generally such an iron is accompanied by lots of graphite floating through the cast house. But what causes the rugged features and the holes in the top of the sample? These are one of the distinctive characteristics that belongs to foundry irons.

The following explanation seems to be a plausible one. High silicon, low sulphur irons are generally accompanied by graphite. Since carbon gives iron its fluidity, the removal of carbon in the form of graphite decreases the fluidity and makes it thick and mushy. All iron contains gases and when a sample of such iron is taken the escaping gases form the holes, or craters in the top. The rugged features are due to the upward pressure of the gases, the holes being left when the iron chills after the gases have gotten out. Due to the thickness of the iron it solidifies immediately leaving the center raised as when the gas escaped.

The next sample to the right is a sample of Scotch iron. This iron analizes—

Iron.

Silicon	3.25 — 4.00
Sulphur	.025— .035
Phos.	.60 — .90
Mn.	.60 — .90

Cinder

Silica	32.96
Alumina	14.76
Bases	47.28 —48.25

Such iron is made in a medium hot furnace, high fusion zone, and low lime. It is at once seen that the feature of this iron sample is its perfectly smooth, level, top. Here is an iron with as high silicon as the previous sample yet it does not resemble it in one way. It is thin like water while the former was thick, it is perfectly level and smooth on top while the former was rugged and full of gas cavities. What is the explanation of the difference?

A shortage of lime on a high fusion zone and cold bottom means free sulphur. Free sulphur and low lime tend to keep the carbon in the combined form and thus give the iron fluidity. It would be hard to get a rugged surface on a dish of water but very easy to get a rugged surface on a dish of mush due to the fluidity. Thin iron is like the water, the gases easily escape but the fluidity of the iron closes up where the gases have bubbled out leaving the surface level and smooth. Boiling water does the same, the steam easily escapes leaving the surface smooth.

The last three samples show the influence of a decrease in silicon and an increase in sulphur. Sulphur promotes the formation of blowholes. Sample seven shows the appearance of sulphur in the form of blisters and eight and nine show that the increase has caused the formation of large blowholes. Low silicon high sulphur iron due to a cold furnace and low lime, is always thin and watery. This is due to the fact that the free sulphur keeps the carbon in the combined form and thus gives it its maximum fluidity.

Figure 2 shows plainly the blisters and pits in iron samples due to high sulphur. The grain is close, white and steel looking. Often the sample itself on cooling has a peculiar whitish appearance and with extremely high sulphur the sample will raise in the middle in a high hump. Figure 3 shows the fracture and hump in such a sample.

Such iron is made with high lime, high fusion zone, and extremely cold bottom. The high lime combines with the silica thus lowering the silicon in the iron to a minimum. The cold bottom produces these conditions and the sulphur is left free to go into the iron. The white hard outlines together with the jagged, ragged, edges are also due to sulphur.

On the middle sample of figure 2 a wormlike peculiarity is seen on the left edge. This odd characteristic is caused by the manganese and is formed some time after the peculiarities due to sulphur have finished. Often after a long time shiny metallic balls burst up through the top. This happens a considerable length of time after the sulphur top has set. With an extreme case these shiny balls lengthen out or creep over the top like the worm seen in the figure. Just how the manganese produces this the writer is unable to explain but it seems to be caused by the escaping of a gas, for the worms are hollow. This feature is never present on high sulphur iron which do not have manganese in them.

Design of Mills Rolling Flat-Flanged Beams.

(Continued from Page 8.)

powerful guides must be applied at least in the case of the heavier beams to keep them sufficiently straight when they leave the rolls to lessen the labor of operating the manipulators.

Fig. 9, A. shows the rolls in the position at the beginning of the rolling process. It can be seen that the flanges are developed in a curved form, which was thought to be practical and better than developing them in a straight shape, because, by this method, wear and tear of the rolls was decreased, the beam entered and left the rolls easier and, finally, it was believed, that this method was the only one which would allow the rolling of parallel faced flanges.

The main drawback in this way of rolling **H** beams is to be found in the formation of fins. Although the rolls are adjusted after each pass and thus are held firmly in position, and although the adjustment prior to the last final reduction is made so that the rolls touch, yet, the rolls will and must spring as soon as the beam enters between them. Thus deflection will occur, the pass will open and gaps will be left between the rolls, where fins and grates will be formed.

Since the beam is developed with the flanges bent outward, as was stated before, a finishing stand of rolls is necessary to square up these flanges. This stand necessarily also has four rolls, all lying in the same vertical plane (see Fig. 10). In all stands the horizontal rolls are the driven ones, while the vertical rolls are friction rolls only. It is claimed that in the final pass the reduction in area is small and, for this reason, the rolls will not be deflected appreciably when the beam passes through them. The formation of fins is, therefore, said to be impossible. Under certain unfavorable conditions, however, the pass may be forced open anyway and then fins will be formed here too.

The Sack mill was changed later on as shown in the Figures 11 and 12. Here we have three universal stands besides the roughing mill. (In both figures the rolls are drawn apart, in order to show the working of the beam). In the first universal stand the horizontal and the vertical rolls are alike and symmetrical to each other, while in the second universal stand the horizontal rolls are alike but unsymmetrical to each other and the vertical rolls are different. The universal stand serves only for the purpose of straightening out the bent flanges and is the same as the one shown in Fig. 10.

In the first stand, the ingot, rolled in the blooming mill from its original size to a smaller one of rectangular section, is brought down to a rough **H** shape. As soon as, after a certain number of passes, the groove becomes filled out, the beam enters the second stand where the edges are worked upon and the beam is rolled down to the final section but with the flanges bent outward. The two manipulators are located before and after the second stand and the beam will be turned 180 deg. after each pass. It can be seen that here the work of rolling the beam to the final section is divided over two stands. About the formation of fins, the same must be said as was said above. Yet, in 1908, it was stated that at the trial rolling on the first Sack mill ever built (at the works of the Rombacher Huette in Germany) the beams produced were satisfactory. The mill, however, later on seems not to have worked so satisfactorily because a short time ago it was replaced by a mill of a more modern type, making wide flanged beams also.

In 1889, L. D. York patented a new mill for rolling wide flanged beams in America. The mill consists of one universal stand with two horizontal and two vertical rolls, all lying in the same vertical plane and all being symmetrical to each other. (See Fig. 13). The same objection in regard to the formation of fins and grates must be made here, as was made against the Sack mill. This type, however, is of a certain historical interest, since it was the forerunner of the Grey mill, which will be described in the next article to appear next month.

Washed Metal in Special Steel Making

Washed Metal as Used by the Brier Hill Company to Give Specially Purified Product for Making Higher Grades of Product. Operation and Features of Washing Equipment.

By **HENRY D. HIBBARD.**

The process of making washed metal now followed is in principle that described by Holley before this institute in 1879, as the Krupp washing process. Sir Lowthian Bell also experimented extensively in England during 1877 and 1878 on refining iron and joined his interest with Krupp, the process being often referred to as the Bell-Krupp process. The only plant in this country now operating this process is that of the Brier Hill Steel Company, Youngstown, Ohio. This process may be considered as the sole survivor of the numerous methods conceived for refining crude iron, when the removal of phosphorus from steel-making material was the great desideratum affecting large districts. The east coast of England and all northern Germany, the homes of Bell and Krupp, respectively, could at that time make steel only from imported ores. These processes were in use or in various stages of development 40 years ago and all except the Bell-Krupp received their quietus from the development of the basic steel processes, both pneumatic and open hearth. The aim of the early refining processes was, first, the removal of the phosphorus, requiring a bottom which would give or permit a basic slag. The incidental advantages of increased yield and small fuel consumption were not generally recognized or considered; the aim of the later operations was the saving of the difference in value between low and high phosphorus irons, as well as hastening the removal of the metalloids.

The chemistry of the washing process follows in part that of the puddling process, and indeed washing might be considered as the first half of puddling, since all the non-ferrous elements of the crude iron, except the carbon, are eliminated and the iron is maintained molten until cast. In puddling, the iron loses its carbon as well, and because of that, its fusion point rises above the hearth temperature; it freezes into a pasty malleable form, and is worked at once by squeezer, hammer, or rolls.

Since Holley's paper, important improvements have been made from time to time in both plants and methods for washing iron, and the degree of purification attained is far greater than Krupp accomplished, particularly as to phosphorus, though Bell's results approximated those of the present practice. The costs have been diminished as well.

The use of washed metal is limited. It is in request now only as an excedingly pure iron and is used, first, in acid steel processes, solely for the reason of its purity, as in open hearth and Bessemer steels of high grade; and, second, because of its high carbon content (3.25 to 3.50 per cent) as well as purity, as a carburizer in crucible steel.

The washing plant of the Brier Hill Steel Company (Fig. 1) is placed near one of its blast furnaces, which supplies it with molten crude iron. It consists briefly of a reservoir, a Pernot furnace, a reheating furnace, and a casting machine.

The Reservoir.—The reservoir is about 100 ft. or more from the blast furnace, a runner in the floor of the cast house conducting the stream of molten crude iron to it from the furnace. It has a brick lining 18 in. thick, is of 50 tons capacity, and is mounted on top of the ram of a vertical hydraulic cylinder, which straddles a 100-ton weighing scales. It is provided with mechanism for tilting to pour the metal. Fifty

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Paper before the American Institute of Mining Engineers.

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tons of iron make four washed-metal charges, which take about 1 hour each to work, and, since the blast furnace is tapped every 4 hours, the reservoir provides a continuous supply of iron to the washing plant The reservoir receives iron when at its lowest position, is raised by the hydraulic plunger about 15 ft., and discharges to a short open runner which conducts the molten crude iron to the Pernot furnace. Iron has been held molten in the reservoir 48 hours with the help of a small oil jet, and then washed without difficulty.

The Washing Furnace.—The Pernot furnace in which the washing is done differs in many details from the Pernot furnaces which have been described. In fact, nothing of the original furnace remains and hardly any of the details of the original design, though the general plan is the same. The changes made have resulted in greater durability and efficiency, but even now the cost of repairs is an important item in spite of the relatively low temperature of the operation.

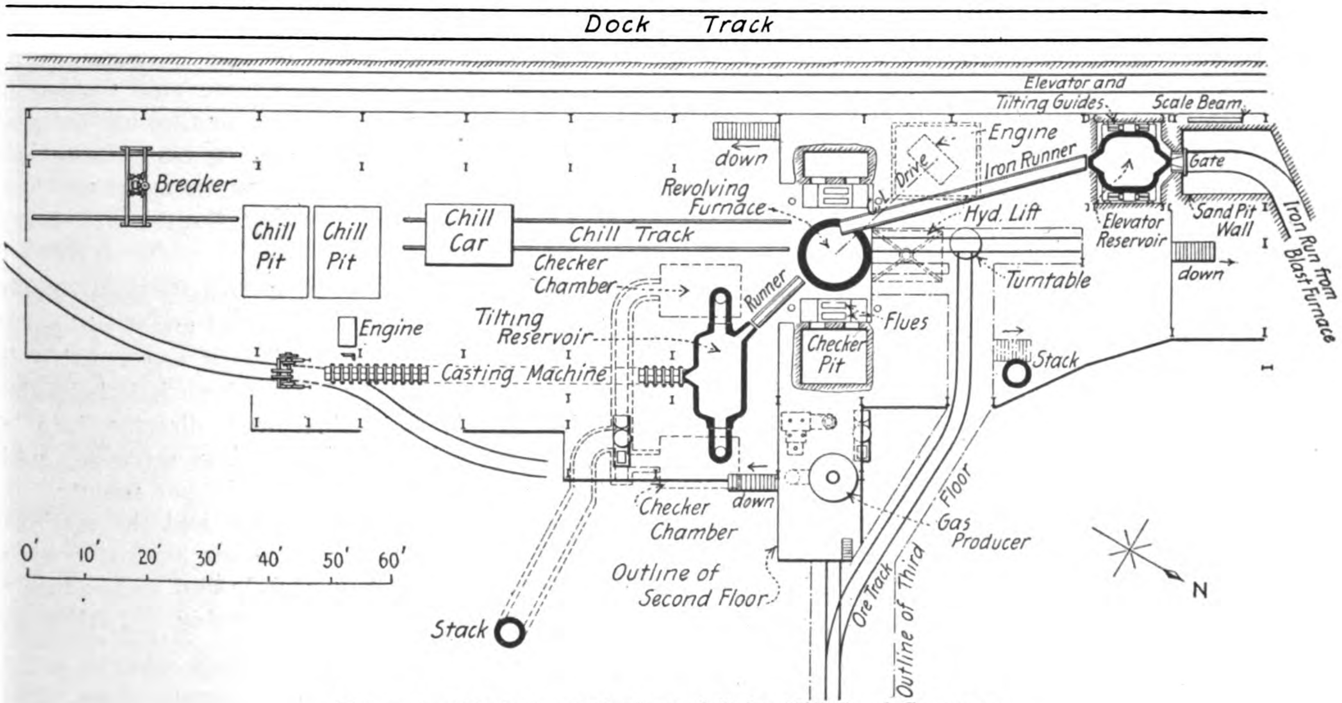


Figure 1.—Washed metal plant of Brier Hill Steel Company.

The pan, as the circular hearth is termed, was originally designed to revolve on wheels, but now runs on conical rollers, which are kept spaced by a spider. The rollers travel on a circular track below the pan, turning in the same direction as the hearth, but at half speed. On the bottom of the pan is a circular track on which it travels over the rollers. The pan is driven by a bevel pinion engaging a gear on the bottom of the pan. The pan lining is so thin (8 in.) that water is continuously sprayed upon the bottom, from underneath, to keep it cool.

In the superstructure, at one side of the single operating door on the charging side and above the pan, is an opening with which the crude iron runner from the reservoir is connected and through which the molten iron is charged into the furnace. In the side of the pan near the bottom is a tap hole and near the top a slag notch. A hole through the furnace roof connects with an ore chute through which the ore is shot for fettling the hearth after each charge has been drawn off.

One circular gas producer supplies gas for the use of the furnace. The ability of a single producer to run this plant depends on the fact that the coal used contains only about 1.5 per cent ash, with 44 to 46 per cent of volatile matter, and will not coke under any circumstances. This makes it possible to carry a fire 8 ft. or more deep, and drive at a high rate with a steam injector for the air, without having above 2 per cent CO_2 in the gas. This coal in earlier days was used raw in the blast furnaces of the neighborhood without other fuel for making pig iron and is in this respect like the Scotch coals.

A section of the floor, 10 by 10 ft., on the charging side of the furnace, is arranged to be lowered, which is done after each heat is run out, providing a place for the men to stand to repair the tap hole and cinder notch, the pan being revolved so that these openings are on the high side.

Operation.—After a heat has been run out, the furnace is drained; any holes in the hearth are puddled out and filled with iron ore, and the fettling, consisting of dampened ore, is run down in successive batches through the roof, the hearth being revolved a little at each dose, so that the bank of fettling is continuous around the hearth. The gate of the ore chute above is controlled by the melter from the working platform by means of overhead levers. While the banks are thus being built up, the bottom is covered with ore thrown by the shovelful through the operating door. The ore used for bottom making and fettling is a high-grade specular hematite, broken into pieces from the size of a hen's egg down, with enough fine ore to make a compact mass without voids.

Between 20 and 30 minutes are consumed in repairing the bottom and fettling. The tap hole and cinder notch are cleaned out and plugged with sand.

The firing is then resumed to heat and set the fix, the reservoir is raised, and 12 tons of iron is run into the pan, which is then started revolving. A reaction immediately takes place between the oxygen of the ore and the silicon, phosphorus, and manganese of the iron, the bulk of these elements being eliminated in a few minutes, by passing into the slag which is formed. The small percentage of carbon which goes off during the operation (3 to 5 per cent) makes enough CO gas to give a vigorous boiling action, throwing jets of slag 3 to 5 in. above the bath at first when the temperature of the bath is greatest.

About 15 minutes after the crude iron has been charged the slag is made to run off through the slag notch. This slag contains most of the oxidized silicon, phosphorus, and manganese from the crude iron, and perhaps a quarter of the sulphur. A second slag is then formed by additions of lime, which, with the ore melted from the fettling, takes up more of the phosphorus and sulphur of the iron. These slags are rich in iron and are therefore smelted afterward in the blast furnaces for making basic pig.

Tests are taken from time to time, averaging about five to a heat, to determine the degree of dephosphorization. The test is a circular cake about 5 in. in diameter and 1.25 in. in the center, being thinner at the edges. This cake is broken into pieces. The test contains a myriad of small bubbles and has a faint crystalline or columnar structure normal to the bottom surface. The lower the phosphorus, the larger the bubbles, and the fainter the crystalline structure mentioned. With very low phosphorus, bubbles as large as 1/16 in. in diameter may be found within ¼ in. of the lower surface, with smaller ones still lower and larger ones up to ¼ in. in diameter near the upper surface.

The whole washing operation takes about an hour, the most of this time being consumed in securing the extremely low phosphorus content required. When ready for casting, the tap hole is turned to the proper position on the pit side of the furnace and is then dug open by means of a hand bar.

The metal runs from the furnace fairly well, but looks cool, almost of an orange temperature, perhaps not over 1,250 deg. C. It gives off copious brown fumes, as well as scintillating sparks and CO gas, which burns, the whole making a brilliant effect and, when viewed from a distance, gives one the impression that the metal is much hotter than it really is.

Casting.—For casting the metal two means are provided: The one generally used when the product is for domestic consumption is a broad shallow cast-iron pan on a car, which runs on a track leading from the Pernot furnace down the center of the cast house. The charge is run out into this pan, where it forms a single plate from 4 to 6 in. thick, and the car is then drawn away from the furnace to cool. Water from a hose is played upon this plate for a few minutes, while hot, to loosen any slag which may come out after the metal and is not trapped off while casting. When the cake of metal is cool enough to be moved without breaking, but is still red hot, it is lifted from the car with a crane and put in a pit. Water is then turned on and it is flooded until cold enough to handle, when it is broken up into one-man size chunks, either with a sledge or by a traveling breaker. This is not difficult, because the water cooling has filled it with cracks, which go clear through the plate. These cracks seem to have no system, except that they are always at right angles to the upper and lower surfaces of the plates, leaving the pieces very irregular in outline.

The other casting method, usually employed for export orders, is to run the washed metal without the slag, into a 12-ton tilting, oil-fired regenerative furnace, located at a lower level, where it is held about 15 minutes, heated, and poured directly into the molds of an endless-chain casting machine, which moves at the rate of about 15 ft. per minute. The joints between the tilting hearth and the stationary ends of the reheating furnace are packed with asbestos, which closes them tightly and will endure the moderate temperature, say 1,350 deg. C., fairly well.

The metal is a little hotter than when it left the Pernot furnace, but is still of an orange heat. In the molds the metal is puffed up by gases being evolved, but settles more solidly soon after being cast, leaving a fin standing up all around each pig. For casting into this form, an extra charge is made.

Yield.—The yield of washed metal is about the same as the weight of the original crude iron charged.

The crude iron contains: Silicon, 1 to 1.25 per cent; sulphur, 0.02 to 0.03 per cent, and phosphorus, 0.090 to 0.10 per cent. All of the silicon and manganese, 90 to 95 per cent of the phosphorus, and 30 per cent of the sulphur are eliminated. The silicon and manganese with 75 to 80 per cent of the phosphorus leave the iron in 10 minutes and 30 per cent of the sulphur in 15 minutes. The silicon, manganese, and phosphorus are removed by oxidation, while the sulphur seems to be eliminated by liquidation, the sulphide of iron getting into the slag mechanically without oxidation. At certain high temperatures, the affinity of sulphur for oxygen seems to be weaker than its affinity for iron. The slag takes sulphide of iron from the metal until equilibrium is established between the proportions of sulphide in the two, when no more will pass. When a second slag is formed, some of the sulphide will enter that, making the elimination from the metal more complete. Should the slag have too much sulphide, as has happened when some blast-furnace slag got in with the crude iron, some of the sulphide will pass from the slag into the metal, and in that way establish the equilibrium.

Individual heats of washed metal have been made having as little as 0.002 and even 0.001 per cent of phosphorus, and it has been furnished on specification of 0.006 phosphorus and under.

When iron heavily charged with carbon, like washed metal, lies molten in contact with molten oxide of iron, there will be, if the heat is high enough, a continuous oxidation of carbon to CO until the temperature falls to a certain degree, when the action will cease. That reaction is endothermic and the consumption of heat automatically brings the temperature down to that point. This temperature has not been determined, but there is ground for suspecting it to be near 1,300 deg. C.

Typical analyses of crude irons with washed metals and slags therefore are given below:

	Pig Iron, Per Cent.	Washed Metal, Per Cent.
Silicon	1.25	none
Phosphorus	0.095	0.010
Sulphur	0.020	0.015
Manganese	.....	none
Combined carbon	.....	3.40
Final Slags.		
SiO_3		16.50
MnO		6.50
CaO		8.50
P_2O_5		1.05
S		0.075
FeO		50.25
Fe_2O_3		16.90
		99.775

Orifices for Gas Volume Testing.

On pages 16 et. seq. of this issue we publish an article under the title "Measuring Gases by a Standard Orifice," in which Professor Estep presents a short and accurate method for determining the flow of large valumes of gas, such as would be encountered in measuring the flow of blast furnace gas or air blast for the blast furnaces. This method involves the use of standard orifices, and with them at hand, simplifies the problem of measurement immeasurably—enabling any plant to check its volumes of air and gas very closely at any time without having to dismantle its equipment or install large amounts of auxiliary testing apparatus. We are informed that the standard orifices for this type of testing work are carried by the Bacharach Industrial Instrument Company, of Pittsburgh, Pa., and that that company has in its possession curves giving the coefficients required for use with such standard orifices.

Effect of Oxygen in Strengthening Iron.

Professor Henry M. Howe, in discussing E. McA. Johnson's paper on the "Chemistry of Oxygen's Strengthening of Cast Iron," published in the March, 1916, **The Blast Furnace and Steel Plant,** offers the following discussion in the Bulletin of the American Institute of Mining Engineers:

Mr. Johnson's explanation, that the rounding of the graphite masses in oxygen-bearing cast iron is due to their being in part re-precipitated after re-solution in forming carbonic oxide temporarily with that oxygen, is certainly most attractive and suggestive. It remains to be shown whether this rounding occurs also when the solidification is too rapid to permit this process to go on. J. E. Johnson might easily test this by casting a single ladleful of his oxygenated iron in masses of varying size. If this present hypothesis is true, then the rounding ought to increase progressively with the size of the casting, and with the distance from the outside, that is to say with the time available for re-solution and re-precipitation.

I question whether a like benefit is to be expected even on this hypothesis, from the oxygenation of steel. The spheroidizing of graphite does good because graphite itself is so weak. But the constituent which can be spheroidized in steel is cementite, which is a source of strength.

Lamellar pearlite, in which this cementite in effect forms long dendrites, is far stronger than divorced pearlite, in which these dendrites have been broken up into spheroids. Even the surfaces of contact between ferrite and cementite are probably sources of strength because of the amorphous iron which probably fills them.

Corrosion of Iron Machinery.

Warner and Davey, in England, have investigated the corrosion observed in iron machinery used in certain industries, especially in the production of illuminating gas. No serious corrosion is caused by the cold ammoniacal liquors, but the tar may corrode the distilling tubes. This is chiefly due to the presence, in the tar, of ammonium chloride, sulphide, and cyanide, which are dissociated at a high temperature. The parts of the tubes that are most rapidly corroded are those which are subjected to irregular deformation from alternate expansion and contraction due to changes of temperature.

A discussion of washed metal, together with a chemical presentation of the removal of metalloids from the metal by washing will appear in the next issue of **The Blast Furnace and Steel Plant,** following the article by Henry D. Hibbard on the process in this month's number. The discussion is based on Brier Hill practice, and presents their solution.

Measuring Gases by a Standard Orifice

Simplifying the Involved Formulae for Finding Volumetric Quantities Flowing Through Standardized Orifices—Adapting the Orifice to the Measurement of Large Gas Volumes.

By THOS. G. ESTEP, JR., Dept. of Mech. Eng'g, Carnegie Inst. of Technology.

To determine accurately the weight of gas delivered in a given time is a problem that is often met with in engineering practice and one that has been rather difficult of solution. Where the pressures are low and the volume of gas small, the ordinary gas meter will answer very well, but where the pressures are high and the volume large, some other means must be used.

Such problems as determining the volumetric efficiency of air and gas compressors, the amount of air supplied to blast furnaces, the amount of a combustible gas used as a fuel in a furnace under certain conditions and the amount of gas flowing in a pipe are only a few of the problems of this kind met with in the various industries.

The standard orifice method of measuring gases lends itself to the solution of such problems with a high degree of accuracy and requires very little apparatus.

The standard orifice is nothing more than a well rounded orifice of a definite shape. Some recent exhaustive experiments have shown that an orifice of a certain definite shape will have practically a constant coefficient of discharge of nearly unity over a wide range of conditions. This orifice can be placed between flanges in a pipe or in a receiver and the gas allowed to flow through it. The only observations that are necessary are the temperature and pressure of the gas before passing through the orifice and the pressure immediately beyond the orifice. Due to the small amount of apparatus and the few observations necessary, this method of measuring gases is almost ideal for field work.

There are two reasons why this method has not been used more frequently; first, because of the difficulty of obtaining standard orifices; and second, the thermodynamic principles underlying the flow of gases through orifices are rather difficult and in many cases, beyond the comprehension of the non-technical engineer. The first objection has recently been overcome, for the writer has been informed that a manufacturer of industrial instruments has decided to carry in stock standard orfices of various sizes. The object of this article is to remove the second objection, to eliminate all technical work in the calculation and reduce it to simple arithmetic.

There are two curves submitted, one for air and one for natural gas, giving a coefficient **K** for different ratios of pressures on opposite sides of the orifice. It is the writer's intention to add curves for other gases at a later date.

The method of procedure is as follows; the standard orifice of known area is placed in position and two pressure gauges attached, one on each side of the orifice. An accurate Fahrenheit thermometer is placed in the gas flow just ahead of the orifice. The pressure on each side of the orifice and the initial temperature of the gas are noted. The pressures must be converted into pounds per square inch absolute, that is, pounds per square inch above a perfect vacuum. The temperature must be converted to absolute temperature. This is done by adding 460 to the observed temperature. The pressure on the flow side is designated as $\mathbf{p_1}$ and the pressure on the discharge side as $\mathbf{p_2}$. Determine the ration $\frac{P_2}{P_1}$ and then refer to the curve and find the value of **K** for this pressure ratio. Then

$$W = \frac{A\ P_1\ K}{\sqrt{T_1}}$$

Where **W** = weight of gas discharged, pounds per second.
A = area of orifice, square inches.
$\mathbf{p_1}$ = pressure just ahead of the orifice, pounds per square inch absolute.
K = coefficient from curve.
$\mathbf{T_1}$ = initial temperature of gas, degrees Fhr. absolute.

A few problems will now be solved to illustrate the use of the curves.

Assume that a standard orifice having an area of 2 square inches is placed in a pipe in which air is flowing. The pressure and temperature of the air before entering the orifice are 150 pounds per square inch absolute and 70 degrees Fahr. The pressure on the discharge side of the orifice is 105 pounds per square inch absolute. Find the quantity of air flowing.

First, the ratio $\frac{P_2}{P_1} = \frac{105}{150} = 0.7$

From the curve, for $\frac{P_2}{P_1} = 0.7$, $\mathbf{K} = 0.492$

Then $W = \frac{2 \times 150 \times .492}{\sqrt{70 + 460}} = 6.41$ pounds per second.

Example (2) Assume a receiver supplied with air at 90 pounds per square inch absolute and 100 degrees

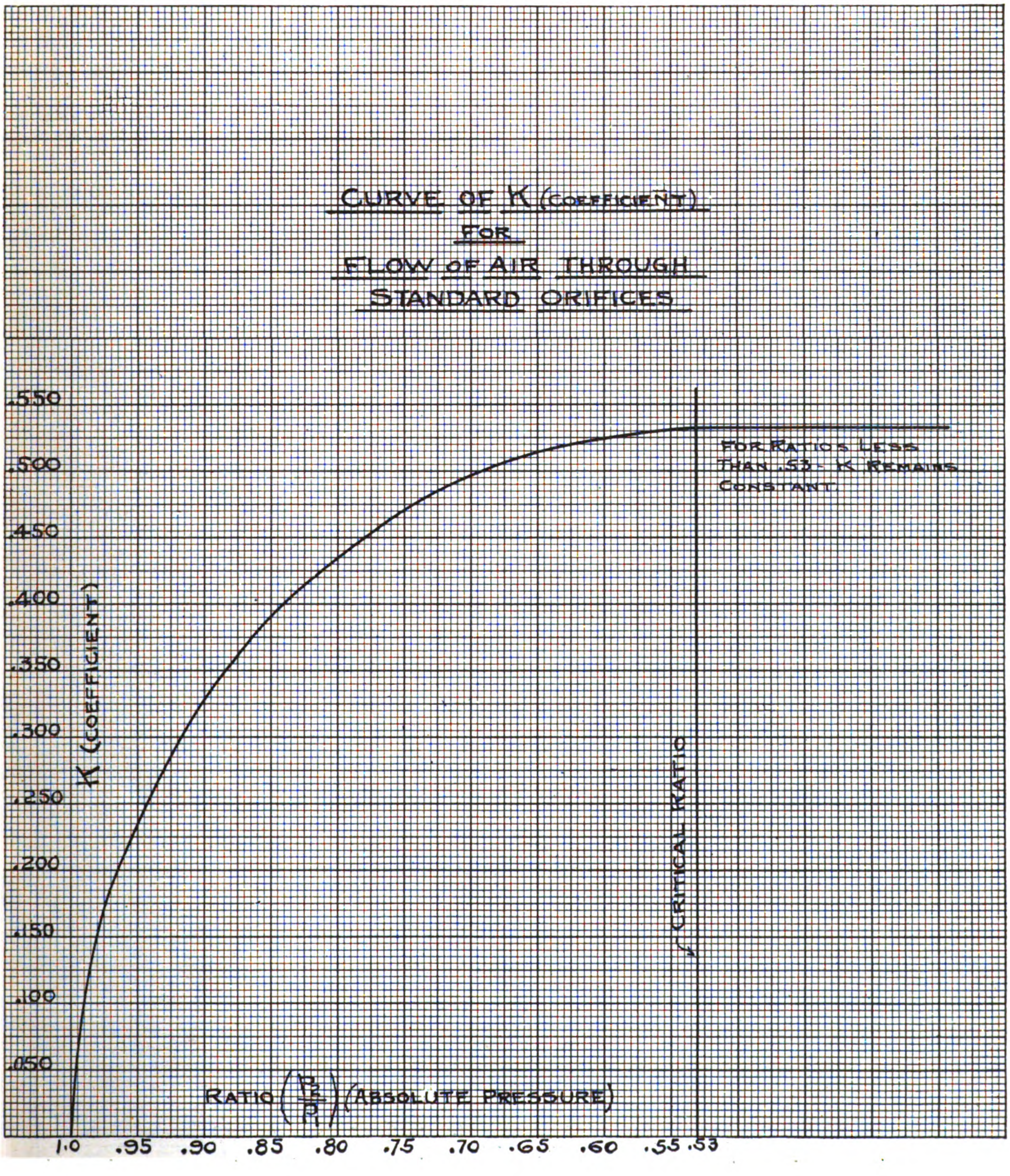
Fahr. Air is allowed to escape from this receiver through a standard orifice of 3 square inches area into atmosphere, the pressure of which is 14.7 pounds per square inch absolute. Find the weight discharged.

In this case, $\frac{P_2}{P_1} = \frac{14.7}{90} = 0.163$

The curve is only plotted to the ratio 0.53 but as will be shown later, for any ratio less than 0.53, the value of **K** is constant and equal to the value at 0.53, so in this case, we disregard the ratio 0.163 and find **K** for the ratio 0.53 which is 0.532.

$$\text{Then } W = \frac{3 \times 90 \times .532}{\sqrt{100 + 460}} = 6.05 \text{ pounds per second.}$$

The curve for natural gas is used in exactly the same way as the curve for air. Note the difference, however, that the value of **K** is constant after passing below the ratio 0.55 for natural gas, whereas for air it is constant after pasing below 0.53. For natural gas,



there is also plotted a large scale, a curve to use when the pressure differences are small and consequently the ratio near unity.

In the problems that were solved, it was assumed that the coefficient of discharge was unity. In practice, this coefficient is very close to 0.98, so that it is necessary to multiply the above weights by 0.98 to get the correct discharge.

Care must be taken in using standard orifices that the flow is steady. If it is pulsating, it must be made steady by receivers and throttling.

Derivation of The Simplified Equation.

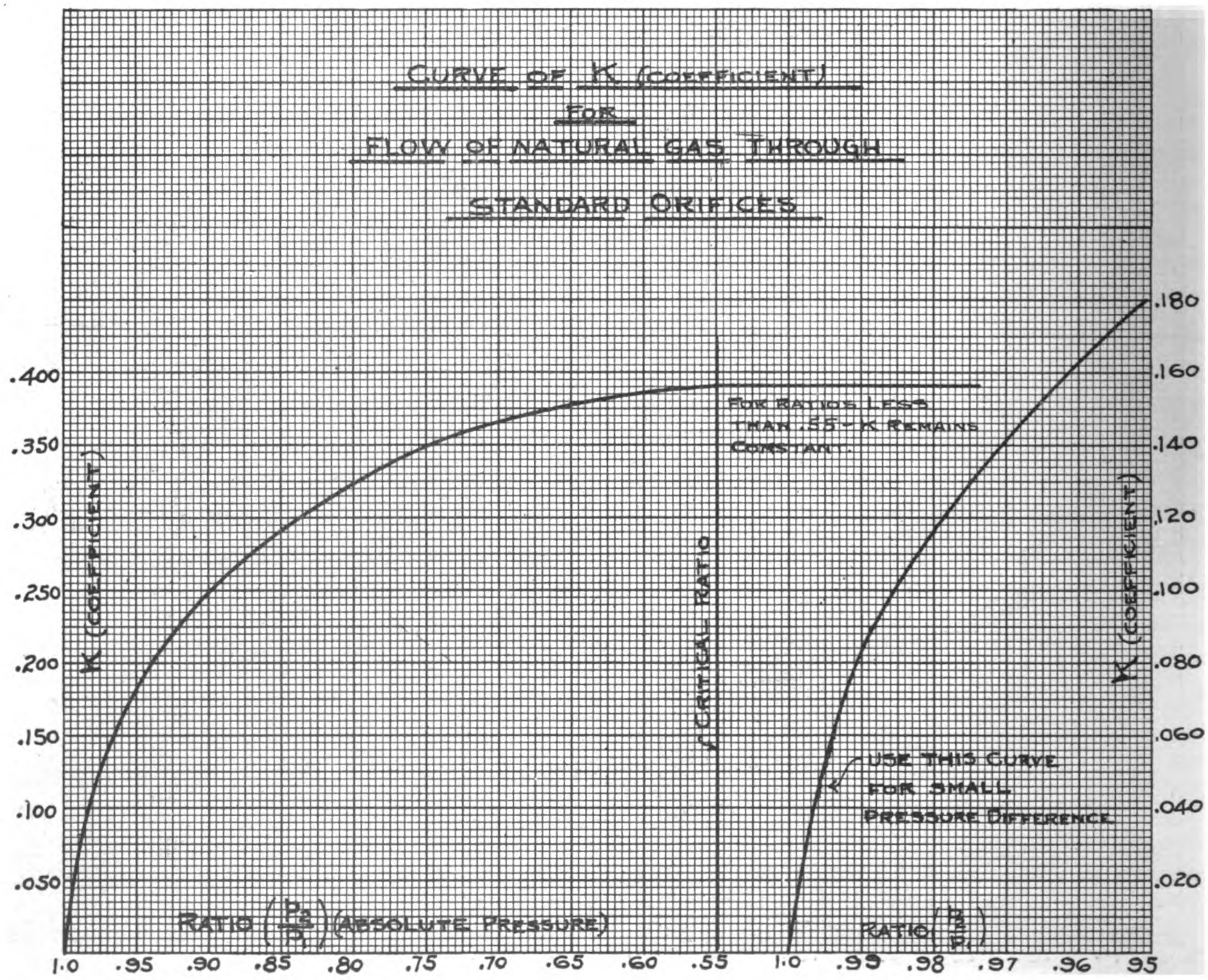
In the derivation of the simplified equation for weight flowing, two assumptions have been made, first, that the expansion of the gas in the orifice is adiabatic and, second, that there is no velocity of approach. The first assumption does not cause any error, for experiments show that this is true. The second assumption will in some cases result in a very small error, particularly where the orifice is located in a pipe and the pressure drop is small. This error can be eliminated but it complicates the calculation so that it will not be taken into account. Under ordinary conditions, this second assumption will not introduce any greater error than that made in taking the observations.

From the theory of the flow of elastic fluids, it can be shown that

$$W = A P_1 \sqrt{\frac{2g}{RT_1}\,\frac{n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{n}} - \left(\frac{P_2}{P_1}\right)^{\frac{n+1}{n}}\right]}$$

Where **W** = weight discharged, pounds per second.
A = area of orifice, square inches.
P_1 = pressure of gas before entering orifice, square inches.
P_2 = pressure of gas on discharge side of orifice, pounds per square inch absolute.
g = acceleration due to gravity, feet per second.
n = ratio of specific heat at constant pressure to specific heat at constant volume.
R = gas constant, different for different gases.

(Concluded on Page 31.)



Late Progress in Hot Blast Stove Design

Concluding Paper Presented Partially in November Issue. Listing and Describing the Important Changes in Stove Structure and Design—Insulation for Heat Saving Recommended.

By A. J. Boynton, Blast Furnace Superintendent, Lorain Works, National Tube Co.

In three-pass stoves and in some recently-built center combustion stoves this construction is, generally speaking, symmetrical, but the symmetry is marred by one or more hot blast and gas passages into centre.

In the side combustion two pass stove the former tendency to build arches through the bottom of the stove, connecting to the checkers through ports whose varying dimensions were intended to equalize friction, has been generally abandoned in favor of pier construction in which no attempt is made to control the distribution, but which by large areas and small surfaces, reduces the friction as low as possible. In this type of stove the chimney valves are usually two in number and set at an equal angle to the centre line of the stove and as far apart as convenient will permit. The blast inlet is usually the centre line of the stove midway between the chimney openings.

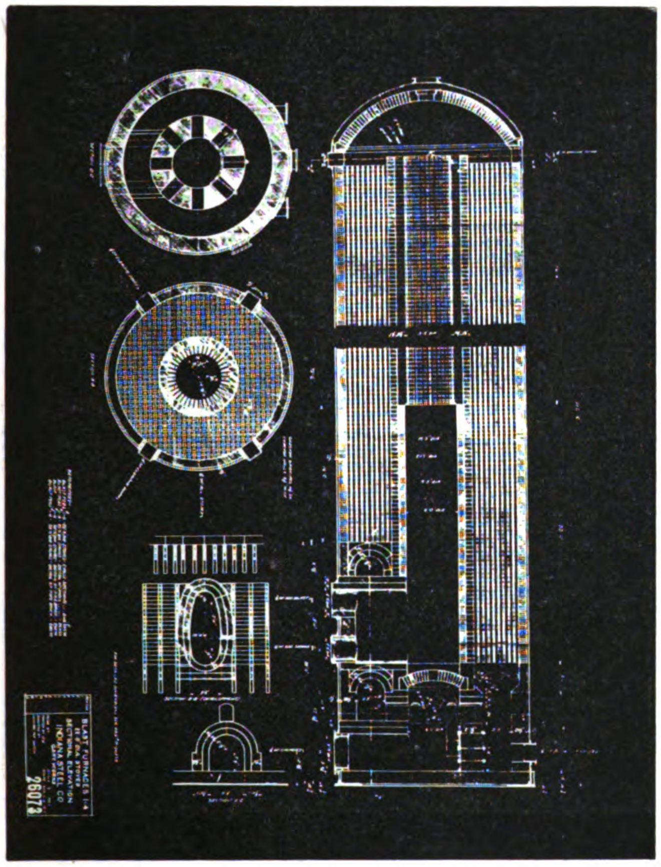


Fig. 20.—New Indiana Steel stoves.

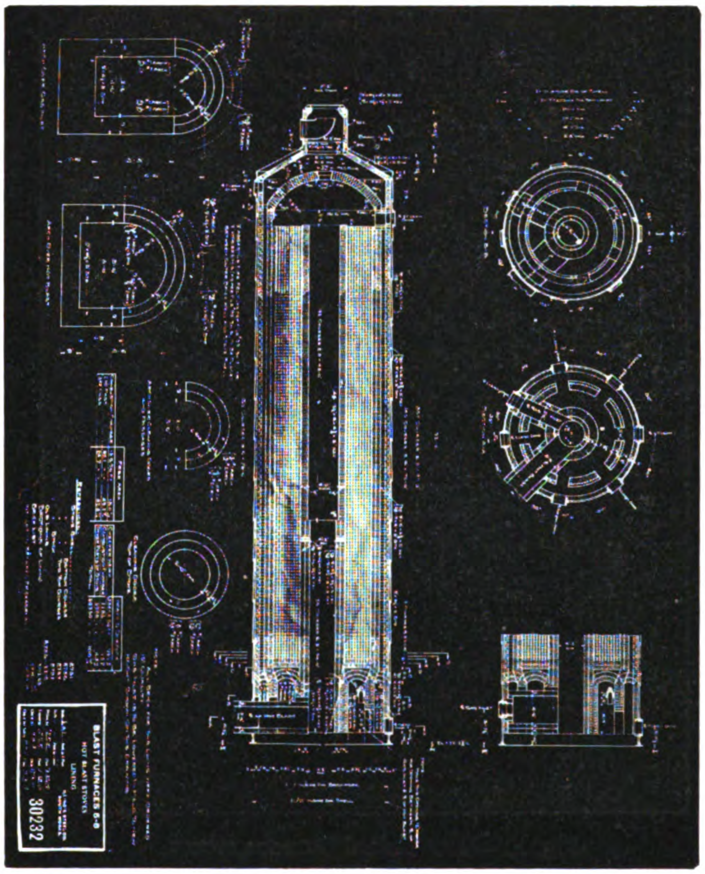


Fig. 24.—Rebuilt three-pass stoves.

Centre combustion two pass stoves when provided with one chimney opening issuing from the side of the stove as formerly built, have appearently shown a poor distribution of air and gas, indicating a considerable effect of difference in frictional resistance. An attempt has been made to remedy this by two diametrically opposite chimney valves, connecting through two flues, one on either side of the line of stoves, into a stack located on their centre line. This construction was symmetrical outside the stove, and a considerable improvement over the single valve from the standpoint of gas distribution, though it had no effect on the distribution of air.

Recent construction provides a generally symmetrical outlet for gas and inlet for air, by a central chamber at the bottom of the stove, with outside connections either through the side of the stove as built by the Illinois Steel Company or through the stove bottom as built by the Carnegie Company at Duquesne works.

The determination of the influence of the gas currents in the dome of the stove as influencing distribution is a difficult matter under high temperature conditions of actual service. Experiments have been made by Mr. A. N. Diehl in connection with the stove previously referred to which with an induced flow of cold air showed a maximum flow through the outer ring of radial checkers, the minimum flow being just outside the ring of checkers next the central combustion chambers with an increase in flow through this inner ring. An inclined baffle wall placed outside the checkers next the outer wall of the stove largely corrected this inequality under the same conditions of observation. The apparent conclusion from these experiments is that the gas current issuing from the combustion chamber continues upward and is deflected outward and downward by the dome. The same conclusion may be derived from Mr. Maccoun's experiments.

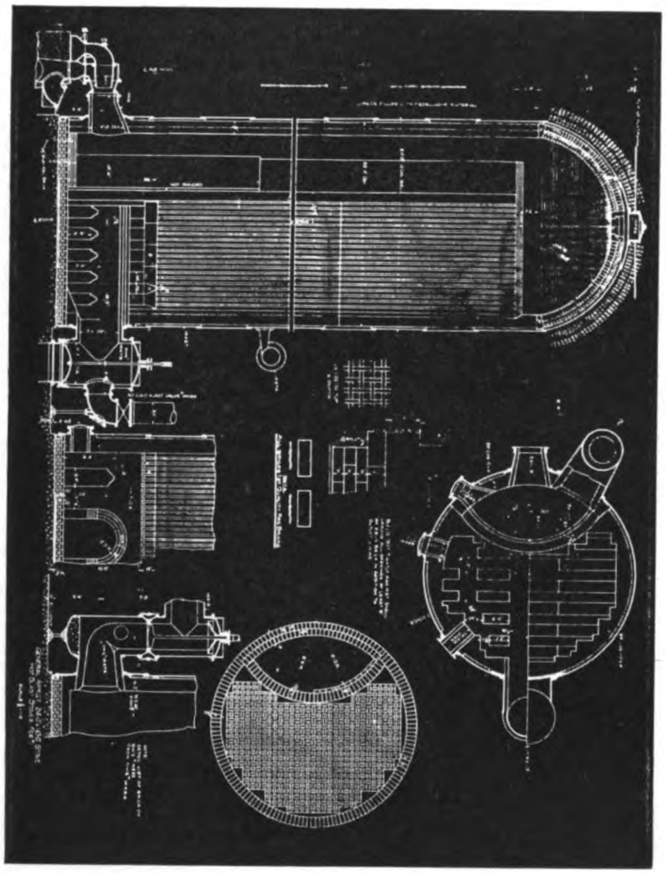


Fig. 12.—New United Furnace stoves.

An exactly contrary view has been taken by other designers, whose object has been to prevent an unduly large flow of gas down the checkers next the combustion chamber. For this purpose the combustion chamber walls have been raised, both in centre combustion and side combustion stoves the wall is usually of a uniform height, but is sometimes varied. The newer two pass stoves of the South Works of the Illinois Steel Company have a fan shaped top to the combustion wall reaching a height of 2 ft. 6 in. at the middle of the wall. These changes to the height of walls have been made as a result of observation of apparent differences in temperature at the top of the stove. Bearing in mind that gas and air are discontinuous bodies, and that all movement of one as well as of the other is the result of pressure; it is difficult to account for a marked tendency for gas to be forced down the checkers next the combustion chamber in undue proportion.

The Size and Shape of the Combustion Chamber.

This chamber with its dividing wall formerly occupied nearly one half the available space inside the side combustion two pass stove. The reason for this is not apparent, since three pass stoves built at the same time were successfully operated with a combustion chamber having less than half the area.

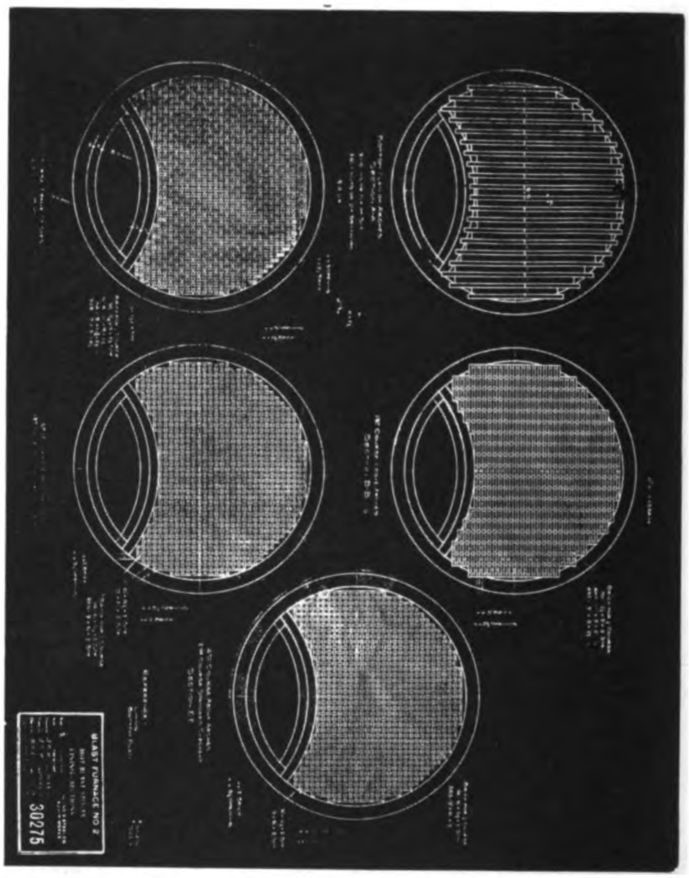


Fig. 11.—Small checker lining sections.

The area of the combustion chamber has been reduced in later stoves, and would doubtless have been reduced to its lowest terms, that is, a cylindrical opening located on one side of the stove if it had not been for a natural conservatism on the part of the designers, as to what the effect would be on the distribution of the gas into the checkers. The side combustion chamber therefore retains much of its former shape and size. As a result of this condition propositions to put checkers in the upper part of the combustion chamber have been frequent. This change has been attended with notable improvement in the case of some existing stove installations. As applied to new construction or complete relining it is readily apparent that no method of putting checkers in the combustion chamber can equal, from the

13[illegible]6

standpoint of available heating surfaces, the reduction chamber to an equivalent area and the resultant ability to utilize this space for checkers, which will extend the entire height of the stove instead of only a part of this height. Distribution of gas is therefore the only apparent reason for an enlarged combustion chamber containing checker work. The free area of the combustion chamber has been reduced to 26.6 square feet in a set of four two pass side combustion chamber stoves at the South Works of the Illinois Steel Company. This area has been proven to be ample through many years experience on three pass stoves.

A very interesting use of space otherwise wasted in the combustion chambers is shown in the construction of the new stoves at Gary Works. Here a saw tooth construction on the inner side of the upper part of the combustion chamber wall is employed to increase the heating surface. This involves no corresponding reduction in the area of the checker since it makes use of the space above the skin wall in the lower part of the combustion chamber.

Structural strength of the combustion chamber walls, is of course at a maximum when the chamber is circular. Any displacement of the combustion chamber walls causes a serious displacement in the checkers. Recent construction therefore tends to approach a circle even in side combustion walls.

Natural or Forced Draft.

The increased friction due to smaller checkers and in some cases to the practice of reducing the area of the combustion chamber by installing checker work has led to the adoption of forced draft for air or gas and recently in one installation for both. There is as yet no general tendency in this direction but there are certain difficulties connected with getting the desired combustion with natural draft which are easily solved by forced draft. Washed gas requires for its successful combustion an intimate mixture of gas and air. This is most usually now done by nozzle burners which require high velocity of air or gas, and, in order to facilitate mixture, the smallest possible proportion in the burner. The result is that where the gas goes into the burner at the slight pressure of the main and the air at atmospheric pressure, the products of combustion will show a pressure considerably below that of the atmosphere, in the bottom of the combustion chamber, resulting in apparent necessity for a higher chimney. A marked drop in pressure through the chimney valve produces the same effect, but this is easily remedied by larger valves. An important requisite in a natural draft burner is, therefore, sufficient area for air, and also a sufficiently large opening from the burner into the stove.

For the usual types of stoves the general practice is still to use natural draft. With larger and more economical stoves, the increased friction and lower stack temperatures are requiring higher stacks, which are however well within the limits of possible construction. For such stoves therefore the chief argument for forced draft is one of better combustion. The design of burners in ordinary use has changed but little since Mr. Diehl's full discussion of the subject before this institute a year ago. The idea of blowing both air and gas into the stove has, however, been reduced to practice since that time at the Joliet works of the Illinois Steel Company. Here an air fan and a gas fan operating on the same shaft and driven by one motor, drive air and gas into the burner of the large four-pass stove described hereafter. The extremely large heating surface, 128,000 square feet, and number of passes of this stove made forced combustion a necessity. A consequence of its use, however, has been an extremely accurate proportioning of gas and air, which can be effected continuously without trusting the judgment of the operator. This arrangement also permits accurate regulation of the amount of gas consumed, according to the necessities of the furnace, and a maximum consumption in comparison with ordinary requirements far greater than that obtainable by natural draft. A second installation for use in two-pass stoves is now nearing completion at Canton, Ohio.

Fire Brick.

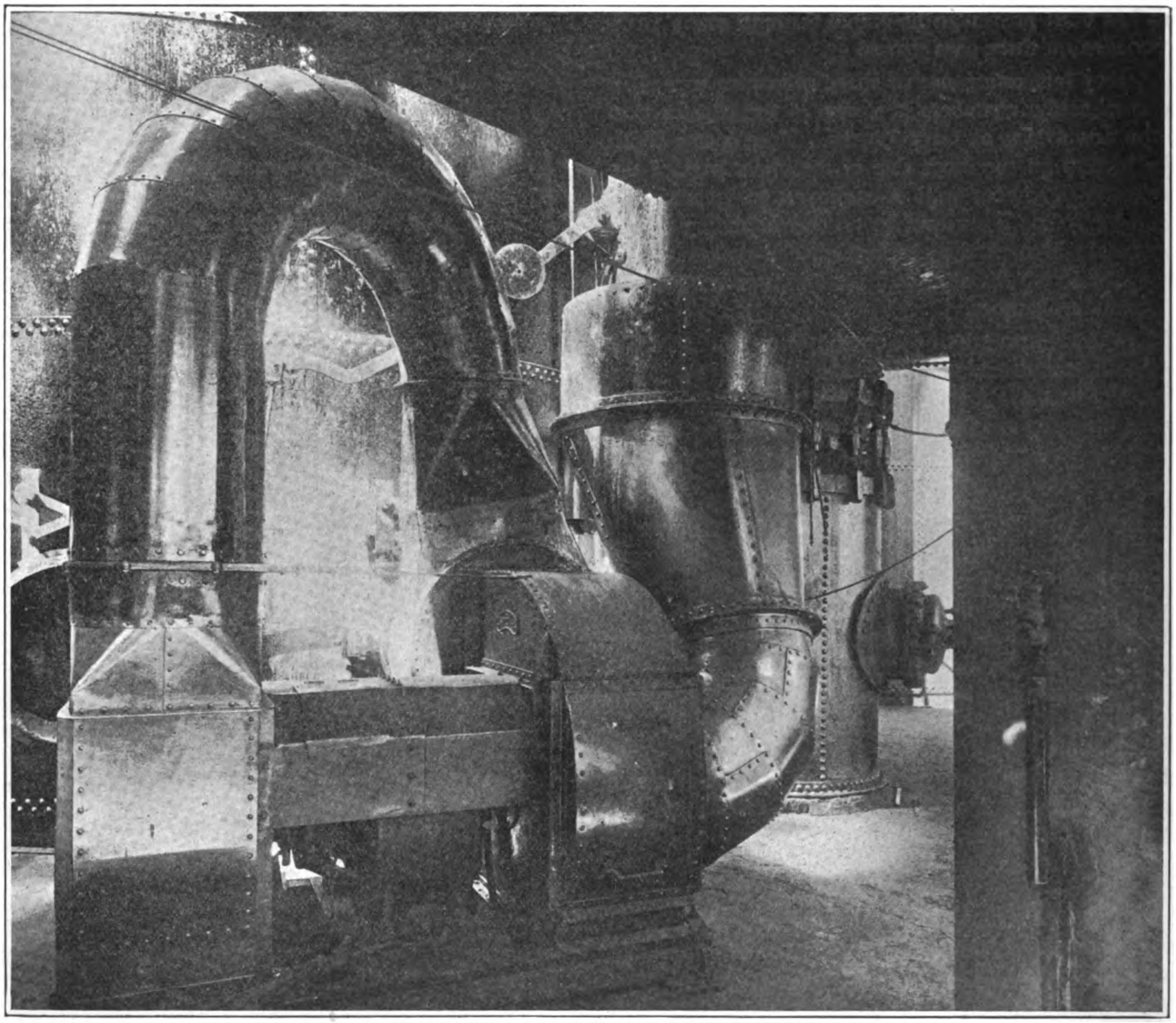
Stove linings are now practically always made of steam pressed and hard burned brick with a tendency to specify first quality brick throughout the stove. These brick withstand the highest temperatures of stove practice without difficulty. There seems to be no good reason, however, why a second quality brick cannot be used in the lower part of the stove. Such brick are stronger, generally truer to shape and are rather more easily heated than the first quality brick. The chief practical difference however, is probably the matter of first cost. Experience with these brick has entirely overcome the idea that regenerator brick should be of coarse grind in order more readily to absorb heat. Small checkers require extreme regularity of size and shape which could hardly be furnished by the old methods of manufacture. The matter of expansion under heat is of the utmost importance, but most of the standard brands of brick now in use give little trouble in this respect.

Insulation.

New stoves are now practically always built with an insulating material between the regular fire brick and the shell. This is partially due to the commercial introduction of insulating materials not formerly in common use, but chiefly to a realization that the losses through radiation were generally in excess of 10 per cent of the total quantity of heat furnished to the stoves. The former general practice was to use an average thickness of two inches of granulated blast furnace slag between the walls and the shell. This was done chiefly to provide for expansion of the brick, but it also acted as an insulator of considerable value.

The materials now commonly employed are asbestos and kieselguhr in various forms. The asbestos is used either in slabs or as asbestos cement. The kieselguhr is used either powdered, in brick made by cutting and drying the kieselguhr rock, or in brick made from powdered kieselguhr. The powdered kieselguhr has in some cases taken the place of the granulated slag, in others this space has been filled either by asbestos slags, by asbestos cement, or by a mixture of asbestos cement and powdered kieselguhr. Kieselguhr brick when used may be placed inside the expansion space, or built next the shell, and kieselguhr powder used in an expansion space between the kieselguhr brick and the fire brick.

Comparative tests have shown that the insulation value of kieselguhr is somewhat higher than that of asbestos for a given thickness. Some designers have preferred the use of asbestos slabs for insulation on the ground that a better mechanical job is obtained by this means. These slabs are made to fit the shell and are provided with an inner cellular space which allows for expansion of the stove lining. This form of insulation is undoubtedly permanent.



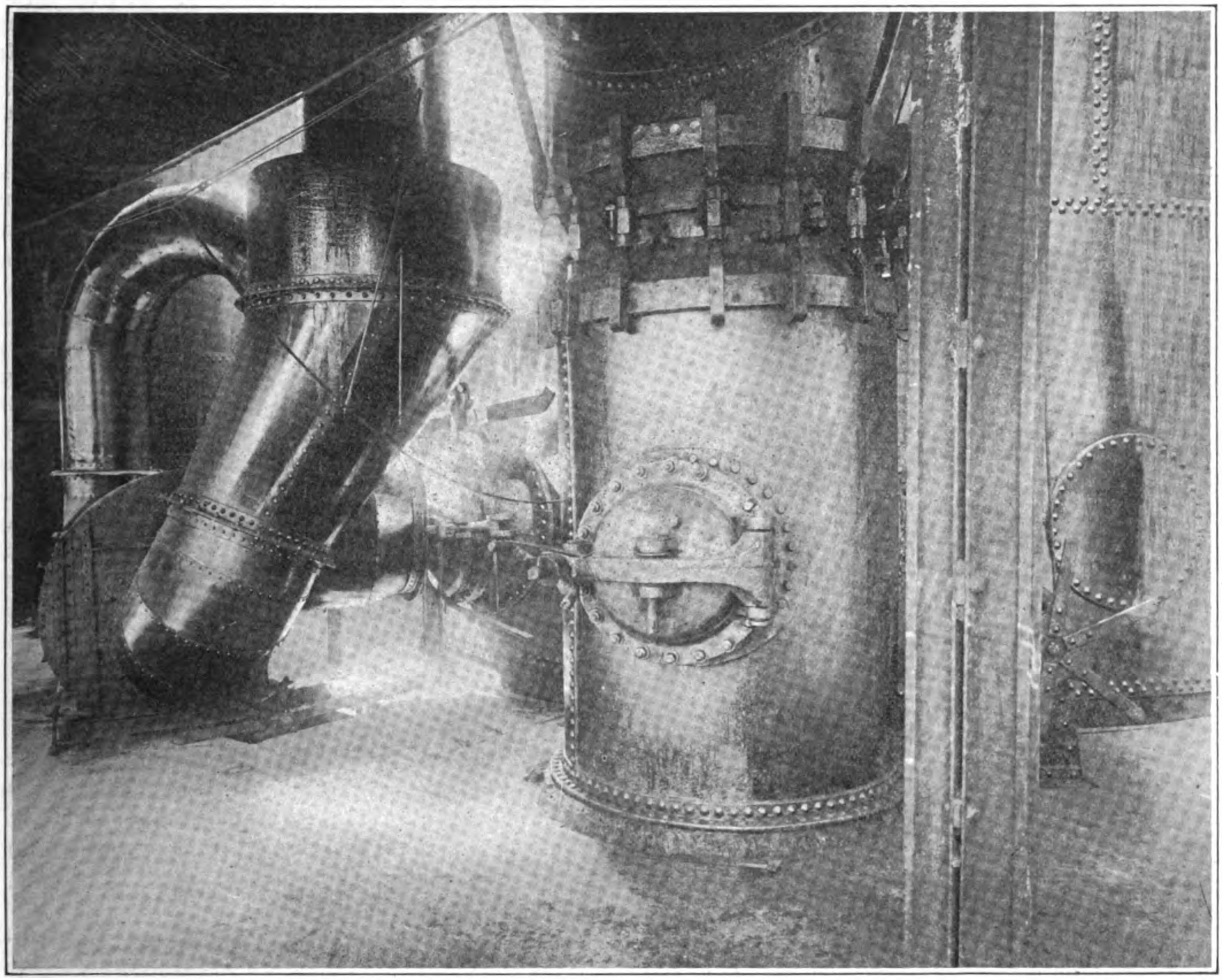
Fan unit and piping for boosting gas pressure.

An often-stated objection to powdered insulation of any kind is its tendency to compact itself inside the stove shell, leaving spaces in the upper part of the stove uninsulated. This objection may be practically overcome for two-pass stoves by building only every second skew back tile of the stove dome against the shell. It has been found that where this is done, shrinkage of insulating material can be made up by additions from the top of the stove. While the kieselguhr brick has a low compressive strength, its light weight makes the strength ample to support a column the height of any ordinary stove. The cost of kieselguhr insulation as applied is less than that of the asbestos. The general use of all of these materials is too recent for any conclusion to be drawn as to the ultimate choice of material.

No reliable data are yet at hand as to the actual reduction in heat loss through the application of insulation to stove construction. There is, however, no doubt as to the value of insulation when forming part of walls of standard thickness. Very naturally there seems to be no tendency to reduce the thickness of walls on account of the less heat conduction through the insulation from structural considerations.

Recent developments have brought only one actual construction of what may fairly be called a new type of stove, the new four-pass stove at Joliet. This stove is shown in Figures 4, 5 and 6. Figure 4 shows general vertical and horizontal cross-sections through the stove. Figure 5 details of construction in the fourth pass, illustrating particularly the method of starting the small checkers of this pass, and Figure 6 shows details of checker work in the three checker passes, together with the peculiar method of laying checkers at the top of the second and bottom of the third pass, which is employed for the sake of distribution of gas. Figure 7 shows the general arrangement of the pressure burner employed. Three stoves per furnace are provided.

Recent two-pass side combustion stoves built with square checkers are typified by installations at the Edgar Thomson Works of the Carnegie Steel Company, at the Joliet works of the Illinois Steel Company, at the Canton furnace of the United Furnace Company, and at the Harbor works of the Inland Steel Company. The oldest of these installations is that at the Edgar Thomson works, shown in Figure 8. This is a conservatively built type of stove, four stoves per furnace being provided, and the mechanical excellence and permanence have been proven by experience with this and other similar installations built about the same time. Similar stoves with five and one-half-inch openings and two and one-half-inch walls have recently been built at the same works.



Another view of gas boosters showing piping arrangement.

Very complete tests made on the stoves shown give a thermal efficiency of 71.58 per cent, with an

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average blast temperature of 1,119 deg. Fahr., and 44,748 cubic feet of air per minute.

Two-pass side combustion stoves as built at the Joliet works are shown in Figure 9. On a relatively small furnace blowing about 30,000 cubic feet of air per minute three stoves have furnished blast temperatures up to 1,200 deg. Fahr., with stack temperatures less than 600 deg.

A method of relining old stoves with small checkers as practiced at the South works of the Illinois Steel Company is shown in Figures 10 and 11. These stoves are of recent construction and not fully in operation. Three of them per furnace are expected to furnish blast temperatures up to 1,300 deg. Fahr. with good efficiency.

New stoves as built by the United Furnace Company are shown in Figure 12, and as built by the Inland Steel Company in Figures 13 and 14. Three stoves per furnace are provided by both companies. These are recent installations not yet in operation.

The use of corrugated checkers in a two-pass side combustion stove is shown in Figure 15, which illustrates the construction employed on one stove at the Joliet works. The economy of use of these checkers is referred to above.

Two pass center combustion stoves have recently been built by the Carnegie Steel Company at Duquesne, by the Illinois Steel Company at Joliet, and by the Gary works of the Indiana Steel Company. The Duquesne stove is shown in Figures 16, 17 and 18.

This construction represents the relining of an existing stove. Test of the performance of this stove on a basis of four stoves per furnace show a thermal efficiency of 70.3 per cent when heating 48,555 cubic feet of air per minute to a temperature of 1,420 deg. Fahr.

The Joliet stove, which also exemplifies the use of corrugated checkers is shown in Figure 19. Practice results with these stoves have been fairly comparative with the side combustion stoves at the same plant.

New stoves now under construction at Gary works are shown in Figures 20 and 21. Four stoves are being provided per furnace. All of these stoves show great care on the part of the designers in providing for distribution of gas to the chimney valve.

Three-pass stoves are exemplified by recent construction of the Corrigan-McKinney Company, at its River furnaces, Cleveland, Ohio, and by rebuilt three-pass stoves at the South works of the Illinois Steel Company.

The Corrigan-McKinney Company stove shown in Figures 22 and 23, represents standard three-pass stove construction modified by reduction in the size of the checkers. These stoves are built four per furnace.

The rebuilt three-pass stoves at the South works show the application of square checkers in the second pass to a three-pass stove. These stoves are shown in Figures 24 and 25. Four of these stoves are provided per furnace.

Very high blast temperatures have been obtained from both these designs of three-pass toves, but data as to thermal efficiency is lacking.

Excepting the first, all of these designs of stoves are interesting chiefly in their details.

The new stoves at Joliet represent an increase to a size of stove not heretofore operated together with some novel features of design. The present stoves are rebuilt inside a shell 25 ft. 0 in. by 100 ft. in height, are a four pass stoves having a six foot diameter circular side combustion chamber, a fourth pass opposite the combustion chamber with the second pass occupying one side of the stove and the third pass the other. Advantage has been taken of the lessened temperature by reducing the size of the checkers in each successive pass after the second, the idea being not only that the volume and velocity of the gases is decreased, but that the service of the brick will be less severe. The second pass is built of 2-in. brick with 4½-in. square openings, the third pass of 2-in. brick with 3½-in. square openings and the fourth pass of 1½-in. brick with 3-in. openings. The second pass contains 362 checkers, the third 492 and the fourth 490, the areas in the passes being, first 28¼ s. ft., second, 51 sq. ft., third, 41 sq. ft. and fourth 30 sq. ft. The total heating surface is 128,500 sq. ft.

One of these stoves is capable of heating 40,000 cu. ft. of air per minute to 1300 deg. F. for two hours, with a heating period of equal length, two stoves being sufficient to heat blast at this rate. The chimney temperature for this performance is less than 300 deg. F. and the apparent thermal efficiency of the stove neglecting radiation is 92 per cent.

The above discussion deals with the general principles in accordance with which recent stoves have been built. The specific questions that confront the designer are with regard to the total heating surface advisable in a set of stoves, and its most advantageous arrangement with regard to number and length of passes per stove and number of stoves.

The demonstration by this installation at Joliet of the practicability of reducing the stack temperature almost to that of the entering blast in a set of stoves whose cost is not greatly in excess of that of stoves showing a much less efficiency, with a use of power in the fan motors corresponding roughly to only ten per cent of the heat saving due to the lowered stack temperature, together with the ability of these stoves to furnish any required blast temperature, furnishes a new standard of stove performance which is bound to exercise a great influence on future design.

The necessity for fuel conservation which is manifesting itself in large investments for gas engines, for waste heat boilers operated by the waste gases both from gas engines and from open hearth furnaces, and for the fullest use of the gas from coke ovens, is equally urgent in compelling not only the use of high blast temperatures, but the greatest possible economy in their generation. The heat actually transmitted to the blast of a modern furnace is about the same as that transmitted to a boiler plant generating 1500 boiler horsepower. The same reasoning has required higher efficiencies of the boiler, and which has in some case condemned the steam plant for lack of efficiency, will require the highest practicable efficiency from the hot blast stove.

All available data points to the conclusion that a given heating surface is best arranged both for heat and for economy when grouped in the fewest practicable units of large size. The chief argument for four stoves is the lessened interruption to operation if a stove goes out of service. On the other hand with only two stoves the furnace shuts down if one stove goes out of service, and a two stove equipment will not come for many years, if it comes at all. The three stove layout however, is elastic enough to prevent severe crippling of the furnace operation when one stove comes off, particularly if it is practicable to force the remaining stove, and in all respects excepting elasticity in operation it is better than an outfit consisting of four stoves. There is, accordingly, a present tendency to build three stoves per furnace.

With regard to the units, the information at hand seems to indicate that a heating surface of 100,000 square feet per stove for three stoves is sufficient for all purposes, although this is necessarily a tentative figure. Such a surface can be contained within a stove of reasonable proportions with any checker sizes now in use, and of ordinary dimensions if the smaller sizes are employed.

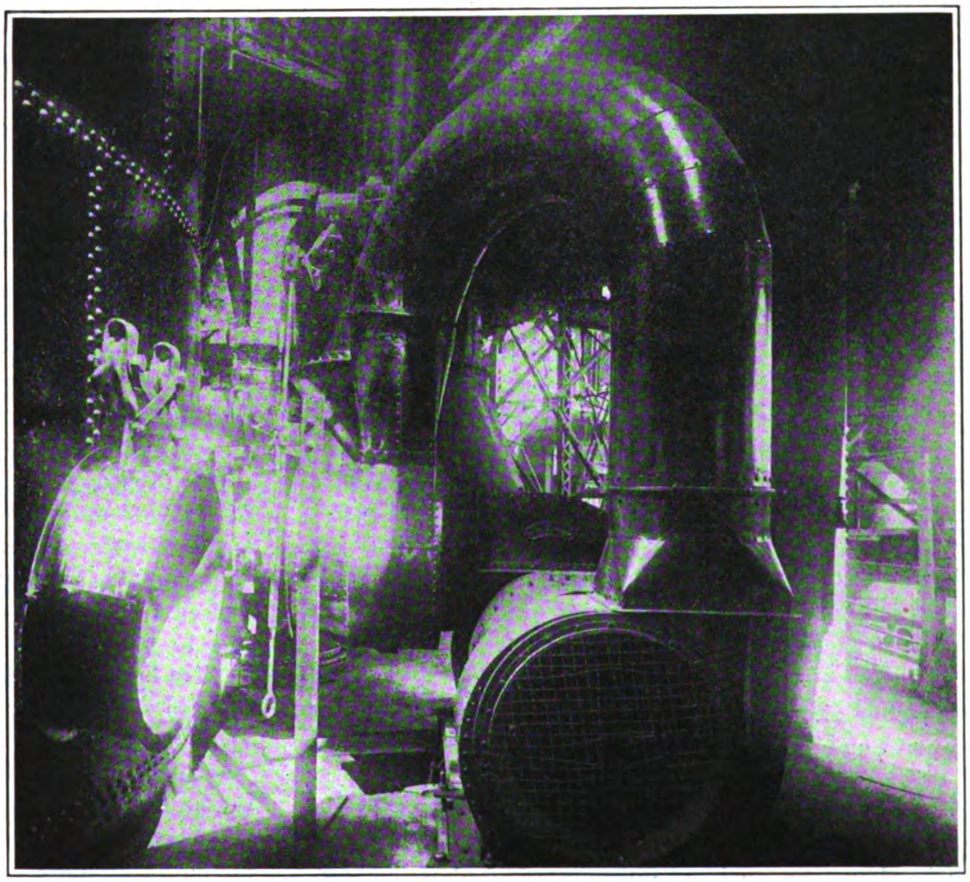
There is no present conclusive reason for advocating one type of stove over another. Two pass stoves will continue in favor on account of their mechanical simplicity, unless the advantage of length of pass, and increased velocity of air and gas in the stove as exemplified in the Joliet installation prove a conclusive reason for changing to a greater number of passes. There are at present no data on which to base a prediction in this regard. The same uncertainty exists as to the relative advantage of increased height or increased diameter in a two pass stove. From the standpoint of first cost based on economical use of materials and of space inside the shell, the advantage is in favor of larger diameter. It is improbable that height will be reduced, but any considerable increase in height will require the same reasons that would apply in favor of a four pass stove.

Recent development may therefore be said to have taken form to date in increase in the capacity of units, and a reduction in their number, together with the application of scientific methods to their operation, the practical results being a very remarkable improvement in furnace practice.

Blast furnace men are united in looking upon this development as a most promising one for the improvement of their metallurgical practice.

(Editor's Note.)

In the above paper Mr. Boynton's figure numbers have been allowed to stand, and the proper notations placed under those used, in order to preserve the continuity of his description.



Fan side of Joliet gas blower.

This paper has been held up by the author since the publication of the first installment, in November, on account of the delay on the part of some outside data. The revision of the manuscript as presented in abstract at the Institute meeting has now been completed, and the matter herein presented represents the complete and final paper, with the exception ot some of the illustrations.

Fuels Available for Metallurgical Furnaces

Considering the Various Fuels Which May Be Used in Metallurgical Operations—Limiting Each According to Distribution and Available Amount—Ideal Fuel Yet to Be Found.

The greatly increased consumption of natural gas for domestic use and for small manufacturing is (either by rise of price or by legislative action) compelling many steel works to discontinue the use of this most convenient fuel. Wherever the necessity of such a change arises, the list of available fuels is scanned with a view to adopting the one best suited for the case in hand. A discussion of these fuels will therefore not be amiss at the present time. Outside of natural gas, the following fuels are available:

Producer gas.
Coke oven gas.
Blast furnace gas.
Crude oil.
Tar.
Powdered coal.

Blast furnace gas is practically never used, although it can be used, if both gas and air are preheated high enough. If the preheating of both is carried to 1,700 deg. F., a flame temperature between 3,500 and 3,540 deg. F. can be obtained. With blast furnace gas of 400 deg. F. and cold air (60 deg. F.), the flame temperature is 2,300 deg. F., which, of course, is much too low for open hearth practice. While preheating to 1,700 deg. F. in the regenerator is not difficult, leakage of cold air brings the temperature down. The attaining of these high temperatures, just before combustion starts, then necessitates very good design and very careful operation. While blast furnace gas is, therefore, a somewhat "difficult" gas at the open hearth plant, it is very well suited for being burned under boilers or in gas engines. It need, therefore, not be considered here any further as an open hearth fuel.

Matters are different with coke oven gas. By preheating air alone to 1,100 or 1,150 deg., F., flame temperatures of over 3,500 deg. F. can be obtained. In this respect, coke oven gas is very similar to natural gas. Higher temperatures of air produce correspondingly higher flame temperatures. Coke oven gas is, therefore, an ideal open hearth fuel which can be used instead of natural gas with very little change. On the other hand, it offers much greater difficulties than blast furnace gas, if burned in gas engines. The result is that coke oven gas is more and more becoming the open hearth fuel in steel plants connected with by-product-coke-oven-blast furnace-plants. Unfortunately, there is as a rule not enough of this valuable gas to go around. For one long ton of steel, from five million to six million B. t. u. are required in the open hearth which, with coke oven gas of 600 B. t. u. per cubic foot, means from 8,300 to 10,000 cubic feet of gas. For each ton of coke, there are produced 7,100 cubic feet of excess gas so that, for every ton of steel produced in the open hearth furnace, there must be made from 1.17 to 1.4 tons of coke. (These figures refer to straight open hearth practice, but not to duplex practice). But a ton of steel requires from .3 to .7 tons of pig iron, depending upon the process used, and a ton of pig roughly requires a ton of coke in the blast furnace. Hence, for every ton of steel produced in the open hearth there are only .3 to .7 tons of coke used in the blast furnace instead of the 1.17 to 1.4 tons which are needed to generate gas for the open hearth. If blast furnace gas is used for heating the coke ovens, the quantity of excess gas can be almost doubled and a quantity almost sufficient can be obtained. But even then there is a deficiency which must be made up by another fuel or by duplexing.

Coke oven gas (and blast furnace gas) enter into consideration at combined blast furnace and steel plants only. All other plants are limited to crude oil, tar, powdered coal or producer gas. The latter has for many years been the mainstay of open hearth plants. Producer gas and air, both preheated to 1,650 deg. F., give a flame temperature of about 3,600 deg. F., depending somewhat upon the composition of the gas. This degree of preheating requires good design of furnace and regenerators, careful operation and a tight furnace. Even then the furnace is slower than it is with natural gas. For this reason, many open hearth men rather dread changing over from natural gas to producer gas.

Tar makes a very good open hearth fuel, if it can be had in sufficient quantities at a reasonable price. Per ton of steel about 35 gallons of tar are required (which, again, means five million B. t. u.) and, since per ton of coke 10.7 gallons of tar are produced, about 3⅓ tons of coke would have to be made per ton of steel, to make enough tar for the open hearth. This deficiency is even greater than that existing with coke oven gas, but tar may be used to cover up the deficiency in coke oven gas plants.

Crude oil is a favorite fuel in detached open hearth plants. Its theoretical flame temperature is high (3,500 deg. F. with cold air), but difficulties of proper atomizing and of prevention of excess air require preheating of the air. The price of crude oil is rather high. In many places 5 to 6 cents are now being paid per gallon which brings the cost of fuel per ton of steel up to from $2 to $2.50. While the present high prices of steel allow considerable profit even with this high fuel cost, many of the works using oil now contemplate a change of fuel for the time, when the present rush is over. Crude oil is not a good substitute for natural gas, except as a very temporary expedient.

The most recent open hearth fuel is powdered coal. Like all other developments in engineering, the development of the use of powdered coal for open hearth work has been slow. Much has been published about some of its features, such as drying, pulverizing, conveying, and storage, but there are other important features which have hitherto remained unpublished. First, the theoretical flame temperature of bituminous coal burned in minimum volume of cold air is 3,600 deg. F. Radiation from the bright luminous flame and the necessity of some excess air depress the flame temperature so much that preheating of air must be resorted to. Under favorable conditions, it is possible to make steel with powdered coal burned in cold air, but the time taken for a heat is quite excessive. No matter how desirable it may be to do away with regenerators, it is not advisable to do so at the present time. It is very much to be wished that somebody experiment with recuperators so as to make the flow of powdered coal continuous and thus simplify the installation. The amount of preheating need not be great. In one plant all checker work was removed from the gerenerator chamber. The preheating obtained by the empty chamber and flues sufficed to make steel, although both time required per heat and coal consumption per heat were greater than with checkers in the chamber.

While for heating furnace work many kinds of coal are available for powdering, the list of available coals for open hearth work is small. Small sulphur content and small ash content together with high volatile content are extremely desirable. Many failures of powdered coal for open hearth work are due to the purchasing of a cheap coal. Regenerators must be so designed that fused ash can be deposited in a removable slag pocket before the flue gases reach the checker work. The latter must be fairly open. Good success has been attained by making the gas passages tubular without dead spaces or projecting corners which may favor deposit. From snowstorms it is known that snow drifts into places where the air is stagnant, and accumulates there. Ash in flue gases does the same. Easy bends of tubular construction and without sudden changes in cross section are therefore recommended.

To avoid deposits of ash, the coal must be very finely ground. The finer the coal, the slower the air current in which it will remain afloat. Installation of grinders much larger than absolutely necessary is recommended, because overloading of pulverizing apparatus causes coarse grinding. If the grinding is fine enough, if the regenerators are properly designed, and if a good coal is burned, practically all of the ash is carried out through the stack in the shape of a scarcely-visible whitish haze. If these precautions are not used, and particularly if a cheaper grade of coal is used, frequent repairs to the furnace and regenerator are necessary; in some places the regenerators have to be cleaned out every four weeks. There is, consequently, no saving in using a cheap coal, particularly in times of great demand for steel. The production lost due to frequent shut-downs pays several times over for the difference in the price of coal. Even with the best grade of coal, the fuel cost is very much lower than it is with oil, and considerably lower than it is with producer gas. With gas producers, the coal consumption is 23 to 32 per cent of the steel output (b weight), whereas with properly powdered coal, the consumption of fuel goes down 18 per cent or more.

From these notes the general tendency may be observed. New steel plants with by-product coke ovens will use coke oven gas and tar in their open hearth plants. If duplexing is practiced, there will be enough of these fuels to go around. Steel works without coke ovens will drift toward powdered coal in districts and toward oil in oil districts.

Bethlehem Acquires New Plants.

Besides acquiring the property of the American Iron & Steel Manufacturing Company the Bethlehem Steel Company has also taken over five blast furnaces, and further control of the Cornwall Ore Banks and also the Cornwall Railroad, represented by the ownership of and leases held by the Lackawanna Iron & Steel Company, Lebanon, Pa. The negotiations are about concluded, and it is expected that the Bethlehem Steel Company will take title as of January 1.

The blast furnaces include the two Colebrook furnaces owned by the Lackawanna Iron & Steel Company and rated at 130,000 tons of pig iron annually, and the two Bird Coleman, and the one North Cornwall furnace, all three at Cornwall, Pa., with a combined capacity of 115,000 tons, which were held under lease by the Lackawanna Company. At the Colebrook furnaces are 232 Otto-Hoffmann by-product coke ovens and a benzol plant.

The ore acquisition means that in addition to holding a majority control of the Cornwall Ore Banks through the purchase of the Pennsylvania Steel Company, the Bethlehem Steel Company will now have substantially complete control, as the Lackawanna Iron & Steel Company had a one-sixth interest in the ore property outright, with an additional voting interest of about one-sixth. The Cornwall Railroad, which goes with the sale, is 13 miles long and owns 172 cars.

According to an announcement by James Lord, president American Iron & Steel Manufacturing Company, the price paid for the latter company was $6,556,800.

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Influence of Cooling on Service of Rails

Addenda to the Report Published in the September, 1916 Issue Undeh the Title "Rolling Cause of Rail Failure in Service." Showing the Influence of the Cooling Bed and Rail Placing.

By DR. P. H. DUDLEY.

A collection should be made of rails which have failed due to the development of induced interior transverse fissures in the track, for the study of the intergranular type which occurs in an occasional "low" rail from the hot beds, also for the coalescent type which occurs in an occasional "high" rail from the hot beds.

The appearance of each type of fissure in the ruptured rail is so different that the similar relations of the contributory causes are not at once apparent.

Collections in museums are made for each department of science, whether geologic, mineralogic, metallurgic, etc., and similar collections of materials which have failed, should be made by each department of a railroad.

The railroad companies in their comprehensive requirements of construction, operation and maintenance, utilize every branch of applied science, besides drawing upon the experience with materials by each of its respective departments. The laws of the mechanics of materials are derived from the knowledge of their use and for the essential progress from year to year; the acquired service tests must be analyzed and classified for future requirements. This involves, besides the daily routine work of the laboratory, research work upon material which has failed under less than ordinary use, and requires a knowledge of each process of manufacture and service.

The passes in the rolls for the hot blooms and rails are turned to "hot templets" which provide 3/16 of an inch per foot for the shrinkage to cold metal. These are 6 3/32 inches high, and other dimensions in like proportion for the 6-inch 100-lb. hot rails and when rolled are sawed 33 ft. 6 3/4 inches long, then cambered—the head curved around the base—and run to the hot beds to cool. (See Fig. 1.)

The shrinkage of the hot metal of the rail is more than the simple process of the gradual reduction of length and volume as the temperature falls, for the transformations of the metal from the higher to the lower temperatures should be practically complete through the recalescence at the critical range in cooling. This is accompanied by the the unique phenomenon of a rise of temperature during the recalescence with re-expansion of the metal at its critical range of temperature, and both should occur, though sometimes they are only partial in an occasional rail head.

The metal in the wide base, though it may contain the same area or more than the massive head, undergoes recalescence first, and its re-expansion curves the base around the head until it is practically straight, but continues to curve until the rail becomes "low" on the hot bed. (See "low" rails, Fig. 1.) Then the metal of the head starts to recalesce, re-expand and curve around the base, straightening the rail for a second time, and continues until the head generally is curved around the base, more than the original camber. (Fig. 1.)

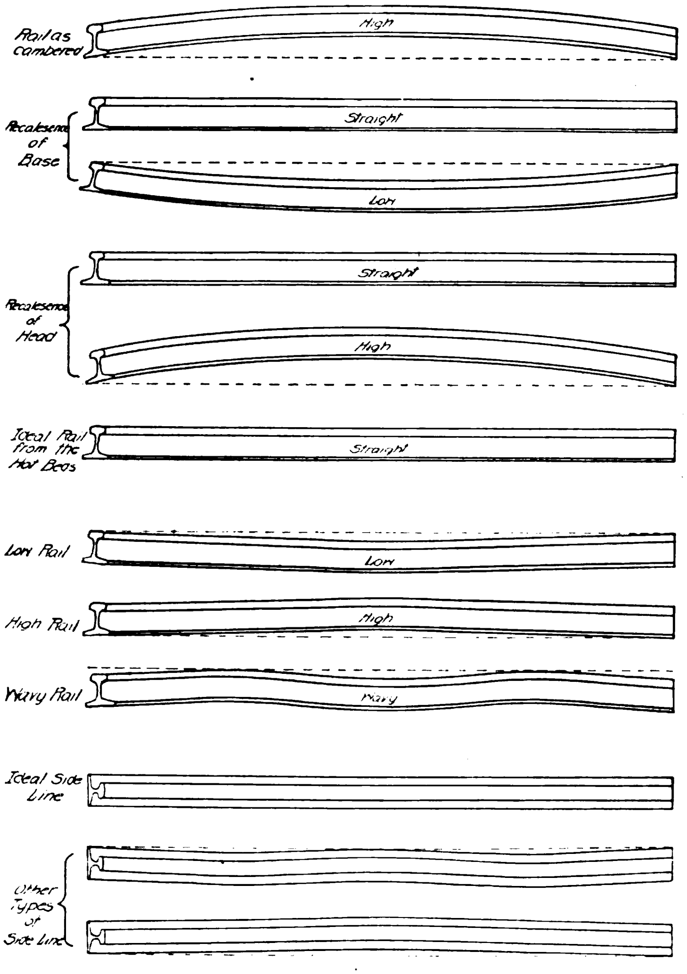

Fig. 1.—Typical curves of cooling rails.

The rails from the hot saws when bunched on the hot beds per ingot or bloom (see upper half Fig. 2), do not cool as smooth in surface or line as illustrated in Fig. 1. The drawing is one I prepared in 1894 of the cooling

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Addenda to report furnished the Board of the New York Central Railroad by Dr. Dudley, who is consulting engineer for the company.

curves made by my 4¾-in. 70-lb. rail as they occurred upon the hot bed when spaced about 6 inches apart during the successive recalescence and re-expansions of the base and then the head. The section when hot was not stiff, and a few of the rails were slightly bent by the two hooks drawing them upon the hot beds, producing the wavy rail. The hot 5⅛-in. 80-lb. rail and 6-in. 100-lb., being stiffer, hardly developed, upon the same hot bed, a wavy rail in cooling.

The rails at the mills—with one exception in this country—are bunched per bloom or ingot on the hot beds, without the requisite attention given to the proper spacing for uniform cooling. (See Fig. 2.)

The rails upon the hot beds when spaced about 6 inches apart, are free from contact with adjacent rails during recalescence and the successive curvings of the base and head, and cool nearly straight, thus the rails require only a few light blows in the straightening presses to correct the surface and line.

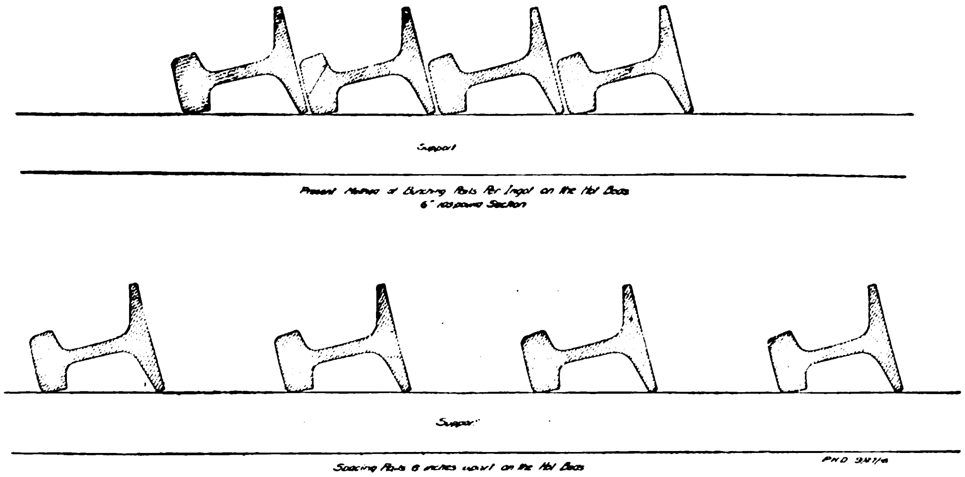
Support
Present Method of Bunching Rails Per Ingot on the Hot Beds
6" 100 pound Section
Support
Spacing Rails 6 inches apart on the Hot Beds
PHD

Figure 2.—Bunching and properly spacing rails for cooling.

When the rails are bunched upon the hot beds, the heat of adjacent rails helps to expand the base, more than should take place and forces an excess curvature to the head, which the recurving from its own metal does not correct. (See Fig. 1.) The central rails of the bunch do not recalesce in unison with the outer rails, therefore an irregularity of spacing takes place with unequal cooling, also unequal recalescence, and the rails require several blows of the gag under the straightening presses to straighten them.

The metal of the rail head after recalescence still continues to lose temperature and in 20 to 25 minutes, or 35 to 45 minutes after the rail reaches the hot bed, it is expected to cool nearly straight. This is rarely the case, however, and the rails need correction for surface and line under the straightening presses.

Induced interior transverse fissures which occur in an occasional rail head, show by my research, the association of a physically non-ductile core or metal near the center of the head, often under strains of tension, and some times with portions under strains of compression. When the core is under strains of tension in a "low" rail it may be checked by the gag in manufacture, or uncapped in a "high" rail.

The fissure, after the rail is laid in the track, commences to develop from the circumference of the checked core or imprint of the gag, for the ordinary strains of service become abnormal. The other portions of the same rail may not enclose a core or portion of such metal, while in other rails which have rolled cold, the non-ductile core or metal may extend nearly its full length, as shown by several rails which have been tested under the drop. (See upper rail, Fig. 3.)

Fig. 3: The upper half of the figure shows an "E" rail from the ingot, "direct rolling," November 3rd, 1910, outside temperature 32 deg. The metal of the entire rail shows that it was rolled cold. The two fissures which are marked "old," caused the failure of the rail in the track, while the other fissures under development were found on breaking the rail under the drop. Intergranular and a coalescent type were found, and by their location indicate the majority of the rail was "low" from the hot bed, though the head was "high" in the quarter of one end.

The lower half of the figure shows an "A" rail, made by "direct rolling" at another mill, December 27, 1910; maximum outside temperature, 36 deg.; minimum, 26 deg. The metal of the rail developed but one coalescent interior transverse fissure, and of the other portion of the rail, two pieces gave 3 per cent ductility, and one piece, 2 per cent.

It is irregularity of the presence of a physically non-ductile core or metal in rail heads, which makes the subject of interior transverse fissures so difficult to trace, and to correlate the facts relating to the contributory causes either of manufacture or subsequent service.

Nearly all investigators have found the physically non-ductile core or metal near the center of the head, and some have not assigned its presence to the contributory causes, but wholly to conditions of service, while others have not offered any explanation whatever for its presence or absence. It should be recalled that the metal near the center of the head is subjected to pressure of the shrinkage in length and volume, and this stress and rigidity tend to irregular delay of the transformations with the unequal spacing and cooling mentioned. The recalesence and re-expansion in length and volume should be equally complete in the central portion of the head with its enclosing envelope, otherwise a physically non-ductile core in a portion or portions of its length may be left in an occasional rail head on cooling, and the core may be under initial strains of tension or compression with its enclosing metal and cause irregular ductility.

We are dealing with a physical condition when the metal near the center of the head is non-ductile or heterogeneous from delayed transformations, while it should be homogeneous from the same chemical composition. These are recent facts as ascertained by isolating the nonductile core which is sometimes found in nodes in the heads of rails, and from which interior transverse fissures have developed in the track.

Rolling rails cold or by too rapid cooling upon the hot beds, is not generally understood as a condition of manufacture of basic open hearth rails which may affect the physical condition of the output. The specifications of the New York Central Lines for basic open hearth rails by their elongation and exhausted ductility tests, disclose the loss of ductility for the composition of the steel either due to brittleness or the crop being chilled, and the rails are rejected when below the stipuated per cent for the melt. The loss of uniform ductility by direct rolling in an occasional rail from the hot beds due to delays, cold rolling and irregular cooling by gusts of air by changing the spacing during recalescence, is more difficult to trace, and the conditions which might induce them should be eliminated in manufacture.

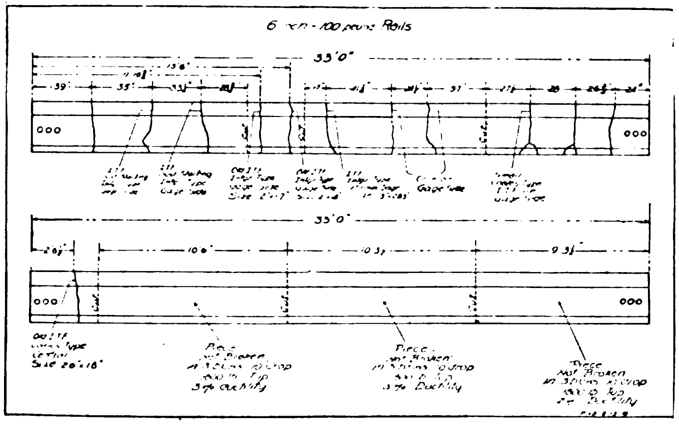

Fig. 3.—Drop test results showing fissures.

Interior transverse fissures from hooked ends of rails from the hot beds two or three feet from the ends of rails, form a large percentage of those which occur, and cores only as nodes at the rupture have been found to date. Trials were made August 26, 1914, to produce a hooked end on cooling rails upon the hot beds by the application of water to the base, ice to the base, or blowing air upon the base when the outside temperatures were between 80 deg. and 90 deg. Therefore chilling the rails in rolling or cooling upon the hot beds, would not be probable. Nine rails from five different melts were treated upon the base as described, though cooling of the head was avoided.

The base and head of the rails treated with water or ice, were not curved, and a hooked end was produced on only one of the three rails upon which air was blown. These rails were all gagged as usual in their manufacture, and the 9 rails were laid in September, 1914, on the high and low side of a 15 deg. curve.

These were worn out and taken up in the latter part of May, 1916, then sent to Beacon, N. Y., to be tested, head down, with a tup of 1800 lbs. falling 12 ft. They were broken into short lengths, and in none of the pieces was a central core found underneath the bearing surface. Each piece showed from 2 to 4 per cent ductility in the rolled bearing surface of the head, which indicates that the wheel loads to wear out the rails, had not concentrated decided strains in the metal beneath the bearing surface.

All 80, 100 and 105-lb. rails in which fissures develop in the track, are sent to Beacon to be tested under the drop, as above described. The majority of the rails show some ductility in the rolled bearing surface, while other specimens which break without ductility, the fracture radiates from a core below the bearing surface (Fig. 3.)

Additional fissures just starting are found in some rail heads on breaking them under the drop. Rails from the same melt, adjacent to the one which developed a fissure in the track, are also sent to be tested, and in several of these which have been subjected to the same wheel loads as those rails in which fissures developed, neither cores nor fissures were found.

A non-ductile core has been found in a new rail which was being gagged under the straightening presses. The core broke, the fracture radiating from it, the blow being sufficient to fracture the entire section.

Fig. 73 of the original shows the remains of two cores about 5/8 of an inch apart, for twin fissures, started in the head in three different places in this 5⅛-inch 80-lb. rail, while a third nucleus was found upon the opposite end of the same two-inch piece on the non-gage side without connection with the others. The cores were in short nodes, but not in continuous lines as to position of location in the head, which indicates that the cooling of the interior metal and its transformations were subject to irregularities. The rail was rolled March 9, 1914, outside temperatures 17 deg. to 25 deg., laid in the track on the inside of a curve, and had carried 45,000,000 to 50,000,000 tons on principally cast-iron wheels.

A 6-inch 100-lb. rail just received shows twin fissures, and upon breaking into short pieces, twin cores have since been found. The metal indicates that it was rolled cold, January 25, 1911, with outside temperatures of 23 degrees to 36 deg. F. Isolating cores in the failed rails becomes valuable in tracing what happened to the metal on the hot bed.

Pieces from the heads of three more 100-lb. rails of two different brands, by direct rolling, have been nicked by a saw for two or three inch lengths, and upon breaking, disclosed twin fissures or twin cores, one in each side of the head, as illustrated in Fig. 73. To date, these twin or single cores as found, are in short nodes lengthwise in the head. The continuity of these cores through the rail head is often interrupted at intervals where the transformations of the metal have been more complete,

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while in some other portion of the head they may remain continuous. This irregularity in the transformations in a portion of the metal in an occasional rail head, is a new development in this research.

It should be borne in mind that by direct rolling of an ingot in part, from its own equalized heat to the finished rail, of basic open-hearth steel of the usual composition of 0.62 to 0.75 carbon, and manganese 0.70 to 1.00, that the metal retains some effect of the roll pressures which shape and extend the length of the bar in its various passes to the finished rail. Transformations of the metal in these basic open-hearth rails by direct rolling has not been investigated as thoroughly as the transformations of metal in small bars which have been re-rolled two or three times.

The fissures do not all occur on the gage side; about 27 per cent in the 80-lb. rails are found on the opposite side of the gage. See upper half of Fig. 2 which shows that only one side of the head would be affected by the heat of the web of the adjacent rails. The rails are usually turned over after the recalescence of the base, and the upper side of the head as shown, would then become the lower side on the hot bed suports. Nearly 15 per cent of the intergranular type which have occurred in the 100-lb. rails, are opposite the gage side.

To see whether or not interior transverse fissures would develop in ungagged rails, 115 105-lb. rails were selected from the hot beds, with but slightly vertical or side curves and without gagging to straighten them, laid in the track, but the curves in the rails could not be spiked out by the trackmen, therefore the rails are not in surface or line and do not ride well.

Improvements should be made in the hot bed work, also the supports in the straightening presses should be widened which would require less pressure of the gag to straighten the rails of heavy and stiff sections. There should also be regularity in rolling without delays to an occasional bar to avoid the rails being rolled so cold that they are liable to be chilled, particularly where the mill is subject to low temperatures in the autumn, winter and spring. The records show by the dates of manufacture, that the melts of basic open-hearth steel which are developing induced interior transverse fissures of either type, were rolled principally by "direct rolling" on days in the above-mentioned seasons when the temperatures were near or below freezing. The temperatures on rolling dates are important factors in cooling the rails on the hot beds, and should not be omitted in the correlated facts.

There are hundreds of thousands of heavy rails which I rolled in the winters of 1892, 3 and 4, still under heavy freight traffic, and have carried from three hundred to three hundred and fifty million tons, and not one of them has developed an interior transverse fissure. Arrangements have been made to remove several of these rails from the track and test the metal to see what has developed in their long use. The composition was adjusted for heavy service and after nearly 25 years in the track we will determine what has occurred in the metal near the center of the head, if anything, under the present traffic. The rails in the track now appear to be in good serviceable condition.

The actual proof of service is more valuable to the railroads of the United States than the opinion which has been expressed that every rail, no matter how well designed and made, is subject to the development of interior transverse fissures under the present wheel loads.

Measuring Gases by a Standard Orifice.

(Concluded from Page 18.)

T_1 = temeprature of gas before entering orifice, degrees Fahrenheit, absolute.

In the above equation, for any given gas and for any given pressure ratio $\frac{P_2}{P_1}$ the only undetermined factors are **A**, p_1 **and** T_1 so let,

$$K = \sqrt{\frac{2g}{R}\;\frac{n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{n}} - \left(\frac{P_2}{P_1}\right)^{\frac{n+1}{n}}\right]}$$

Then our equation becomes, $W = \frac{A\,P_1\,K}{\sqrt{T_1}}$

Different values of $\frac{P_2}{P_1}$ have been assumed and **K** found for each of the values and the curves plotted.

It can be shown that the critical ratio is as follows;

$$\frac{P_2}{P_1}\text{ (critical)} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$$

Where **n** equal ratio of specific heats as before. This critical ratio is the ratio of pressures where the velocity of the gas leaving the orifice becomes a maximum, and no matter how much the ratio is lowered from this point, the quantity discharged remains constant so long as p_1 and T_1 remain constant.

The following values were used in the calculations for air;

n = 1.4
R = 53.34
Critical ratio = 0.53
n = 1.27
R = 93.96
Critical ratio = 0.55.

For natural gas;

For natural gas, the analysis was assumed as follows;

C_2H_4 = 0.31
CH_4 = 92.60
H = 2.18
CO = 0.50
CO_2 = 0.26
N = 3.61
O = 0.34

99.80

This analysis given as per cent by volume. The constants were figured on a basis of 100 per cent instead of 99.80.

EDITORIAL

Surtaxing Intelligence.

THE trade journal is recognized by its readers as the most convenient medium for the exchange of ideas and the development of an industry, and as such a factor in the industrial development of the country, has enjoyed certain privileges from the postal authorities. The second class of mail matter, including all publications mailed to subscribers who are on a paying basis—i. e., not receiving the paper complimentary or otherwise gratis—was set apart for journals and publications to insure a national circulation for them at postal rates which would not be prohibitive. Now Congress, as a "rider" on the Post Office Appropriation Bill, has before it a proposition which would seriously impede this much-to-be-desired national growth of the trade journals by taxing them for postage at rates incommensurate with the financial return from the distant subscribers. The bill places a postal rate on all publications based on distance of transmission, as follows:

Up to 300 mi....1c per lb.
300 to 600 mi....2c per lb.
600 to 1,000 mi....3c per lb.
1,000 to 1,400 mi....4c per lb.
1,400 to 1,800 mi....5c per lb.
Over 1,800 mi......6c per lb.

This surtax, if legalized by action of Congress, will operate directly to impair the efficient distribution of the truly national journals, but will cut only a small figure with the daily newspapers, whose circulation is in the main well within the innermost circle of miles as proposed. If national unity is to be secured and maintained in the various trades, the dissemination of all that is new and advantageous must be fostered—but it is manifestly unfair to expect the journal whose field covers operations in California as well as in Maine to pay several times as much to send the magazine to the man who is, merely through geographic circumstance, far away as to the men who are lucky enough to live in one of the eastern industrial or trade centers and consequently nearer the points where conditions combine to make trade journal publication possible.

From the subscriber's point of view the surtax proposed is still more unfair. The man in the new field, far from established production centers, who is striving to develop new stores of raw material, must—if the bill carries—pay a higher subscription rate than the more favored co-worker in the older plant, for no more returns, save a farther travel of his paper, than the eastern subscriber.

The main items of cost in mail handling are not the mileage and ton-per-mile factors; they are the terminal handling and distribution costs. Mail to large centers across the continent can often be carried at less actual expense to the postal department than the same weight of mail can be handled to small offices in the same state as the publisher—due to railroad connections, mail routes and other impending conditions—but the cheap haul must, if the bill is carried, help to cover the unfavorable runs.

If national unity is to be served, there must be every help given toward fostering a national cimmunism in industrial life, toward placing all units of every manufacturing industry on a par through the exchange of betterments and invitations, and toward the removing of the natural barriers erected by distance and unfamiliarity of one manufacturer with the other: for all of which the trade journal must serve, and must be aided to serve without unfair or impending postal legislation or geographical discrimination.

Enlarging the Basket.

SOCRATES, Aesop, or some other equally erudite of the ancient philosophers, once said something to the effect that it was bad policy to carry all the eggs to market in one basket—meaning to advise the distribution of responsibilities. This policy, though time-honored and hoary, is not endorsed unqualifiedly by the modern plant, which is reversing the dictum and gathering into one basket all the "eggs" which are of any use thereto. The recent purchase by a steel interest of large holdings of coking coal is one of the most prominent examples of the desire to combine all contributory fields with the main one of production. Ore fields long ago became, in many instances, a part of the blast furnace's holdings, and oftentimes were responsible for the location of the stack; then the furnace and the steel mill were combined; and now we have the steel mill adding another unit, in the form of a by-product coking installation: which naturally leads to the acquisition of coal lands to insure a uniform and unfailing source of raw material for the ovens. And with this last link in the chain of the modern plant is well-nigh self-contained and independent until the marketing of the finished product and by-products is reached. The recent consolidation of a furnace plant with a rolling mill and finishing unit is but another example of this unification and concentration, and points the way to further savings in cost and reductions in operating overhead for other one-step plants which are finding competition and operating conditions increasingly hard to meet.

PRODUCTION TOPICS

Enriching Blast Furnace Gas.

Dr. W. Zimmerman, of Worms, reports that blast-furnace gas can be improved by blowing it through a coke oven. By experiments he made with a small Otto coke oven, he found that the gas mixture thus produced, for which he suggests the name of "compound gas," contained less carbon dioxide and less nitrogen than when the two gases were mixed cold in the usual way. At the same time, it contained more hydrocarbons, both light and heavy, and consequently had a higher calorific value (in one case as much as 13.6 per cent as compared with the cold mixture). Moreover, passing the furnace gas through the oven over the coked mass lowered the temperature of the nascent coke-oven gas and prevented the decomposition of some of the ammonia already formed, a considerable amount of which was lost, especially during the last hours of the carbonising period. According to the author, the yield of ammonia was increased by 25.2 per cent as compared with that obtained from coke-oven gas in the ordinary way. The cooling of the coke oven did not increase the amount of gas fuel required nor prolong the carbonising period, which is usually 36 hours. Nor did the blowing of blast-furnace gas through the coke oven have any effect on the quality of the coke produced.

Thermo-Electric Determination of the Critical Points of Iron.

When the wire of a closed homogeneous circuit is heated at some spot, a thermo-electric force is not set up. Even when there is a transformation point somewhere at which two allotropic phases are in contact, there need not be a thermo-electric current, because the potential differences at the surfaces of contact will balance one another. For in a thermo-couple, e.g., of Le Chatelier says there is a hot junction between the wires of platinum and of platinum-rhodium, and there are two cold junctions (kept in ice) at the points where the free ends of the wires are soldered to the copper leads, while the temperatures will be equal at the contact surfaces of the transformation point. But there is a probability of such a thermo-electric effect, because every allotropic transformation requires some time to be established; this latter fact probably explains why the transformations generally are observed to take place at higher temperatures when the material is being heated than when it is cooling. Professor Trouton observed in 1886 that a thermo-current was flowing when an iron wire was being drawn through a Bunsen flame so that it became locally heated; in that case the two contact surfaces may differ in temperature, and an effect of thermo-electric hysteresis (the name was suggested by Sir W. Barrett) will be noticed. On these considerations Professor C. Benedicks, of Stockholm, has based a method of determining the critical points of iron which he described before the Iron and Steel Institute last May. Modifying an arrangement proposed by H. Le Chatelier, he moved an iron wire at uniform speed through an electric furnace; any molecular transformations occuring at certain temperatures should set up thermo-electric currents. In this way he observed a marked discontinuity corresponding to the point A_3, but not any corresponding to A_2. The result has induced Messrs. G. K. Burgess and H. Scott, of the Bureau of Standards, to try another modification of Le Chatelier's arrangement, and they have communicated a first account of their experiments to the Paris Academie des Sciences. An iron wire, 7 cm. long, 0.05 mm. in diameter, was stretched in a vacuum electric furnace; each end of the wire was soldered to the junction of a Le Chatelier couple. A galvanometer inserted between the two platinum wires measured the thermo-electric force of the couple iron-platinum for the temperature gradient in question; the two ends of the iron wire only differed in temperature by a few degrees Centigrade. The actual temperatures of the two ends of the iron wire were determined by the potentiometer method. A great many observations, both of heating and cooling curves, were taken at intervals of 2 deg. C., the moments of the observations being determined with the aid of a chronograph. The galvanometer was highly sensitive; but the description of the apparatus does not give any further details, referring back to a previous publication by Messrs. Burgess and Crowe. The iron was very pure, being of 99.968 per cent and containing only 0.009 per cent of carbon, the same amount of sulphur, and smaller amounts of copper, manganese, silicon and phosphorus. The curves mark both the A_3 and the A_2 points very clearly. While the temperature differences between the ends of the iron wire fluctuated between 3 and 5 deg. or between 7 and 12 deg. only, the thermo-electric force rose on heating and cooling to a humped peak and then fell off, gradually and then rapidly, a little above 900 deg. C. (on heating), or below that temperature (on cooling); that is the point A_3. The A_2 point was also distinct, but much more marked as a decided maximum on the heating curve than on the cooling curve; on the latter it was a point of inflexion at 768 deg. C. rather than a maximum. The point A_1 was absent on both these curves, while it appeared clearly in an iron containing 0.1 per cent of carbon. Further experiments with steels and at lower temperatures are to follow.

Iron Coke.

By passing the dust from blast furnaces repeatedly through magnetic separators a product is obtained rich in ferric oxide. One part of this dust is mixed with three parts of caking coal slack and heated to a high temperature under pressure. A porous coke is obtained, containing metallic iron regularly distributed through it. This material might be used for electrodes, or as a filtering medium, or for decolorizing solutions.

Brittleness in Iron Through Sodium Hydroxide.

Wrought iron corrodes slowly, becomes highly crystalline, and eventually brittle by immersion in a concentrated aqueous solution of sodium hydroxide at 100 deg. C. for several months, says J. H. Andrew in the Transactions of the Faraday Society. The corrosion is attributed to electrolytic action between the two phases, crystalline and amorphous, of which the metal is constituted, iron going into solution at the anode (forming sodium ferrite), hydrogen being liberated at the cathode. Part of the hydrogen is occluded by the metal, being first absorbed by the amorphous constituent, thereby forcing the crystals apart, and ultimately causing the iron to become crystalline and brittle. The brittleness decreases with time, an equilibrium being finally established between the metal and the gas, and is due rather to the molecular rearrangement induced by mere occlusion or evolution of hydrogen than to the mere presence of the latter in solution. The potential difference between the amorphous and crystalline phases and hence the rate of corrosion decreases as the latter phase becomes hydrogenized, the passivity of iron produced by immersion in caustic soda being due to this cause. Similar results were obtained with electro-deposited iron, but steel containing 0.5 per cent carbon was much less affected by sodium hydroxide solution. The recrystallization of electro-deposited iron upon cooling through the Ar_3 point is also considered to be due to the evolution of hydrogen.

Blast Furnace Slag Cements.

There are three classes of cement obtained from blast-furnace slag, according to H. Kuhl in "Tonind-Zeit," as follows: (1) Puzzuolana cements, which consist of ground slag, containing 42 to 52 per cent of calcium oxide, mixed with sufficient slaked lime to bring the content of calcium oxide up to 63 to 66 per cent. This cement is hardly superior to a good hydraulic lime, does not harden well in the air, and only feebly resists wear and tear. (2) True Portland and iron-Portland cements: in the former slag replaces clay in the mixture of raw materials used for making Portland cement clinker. Any slags may be used except such as contain excessive proportions of magnesium and manganese. Iron-Portland cement consists of a mixture of 70 per cent Portland cement clinker and 30 per cent of water-granulated blast-furnace slag. In strength and general properties iron-Portland cement is practically equal to Portland cement, but both have the disadvantage of being highly susceptible to chemical action, especially to the influence of sulphuric acid and magnesium salts. (3) Blast furnace cements are prepared by mixing rapidly-cooled and granulated slags, which possess innate hydraulic properties, with a considerable quantity of plaster of Paris. Such cements contain only a negligible quantity of free lime, and consequently offer great resistance to the action of acids and magnesium salts.

Alumina Inclusions in Steel.

By the term "inclusions" (or "enclosures"), the steel metallurgist refers to small particles of non-metallic and generally oxidized impurities mechanically held by steel after it has completely solidified. These inclusions are as a rule lighter than the metal in which they are imprisoned, and if the latter could be kept liquid for a sufficient length of time after their formation most, if not all, of these foreign particles would rise to the top of the ingot or casting. Owing to the very small size of some of them, however, and to conditions of manufacture, a small amount of these inclusions must of necessity be retained in the solidified metal.

The inclusions commonly described comprise silicates, chiefly of manganese and of iron (frequently called "slag"), and manganese sulphide (often associated with iron sulphide). The use of titanium as a deoxidizer may introduce some titanium nitride inclusions, while the use of aluminum for the same purpose may result in the formation of alumina inclusions through the oxidation of some of the aluminum.

The present investigation was undertaken for the purpose of ascertaining whether the occurrence of alumina inclusions in steel could be detected under the microscope and of studying the characteristics by which these inclusions can be distinguished from other inclusions.

Barring one or two unimportant exceptions, says Prof. Albert Sauveur, I am unable to find in the literature dealing with inclusions any reference to the occurrence of alumina antedating Mr. Comstock's article presently to be described. Previous to his writing, alumina had not generally been considered as a distinct or, at least, as a distinguishable inclusion.

Referring to the use of aluminum as a deoxidizer, however, and to the resulting formation of alumina, Rosenhain writes:

> "A more powerful deoxidizing agent than manganese is furnished by aluminum, but this differs from manganese in two vitally important respects. In the first place, the oxidation product of aluminum is a particularly refractory substance—alumina—which has a strong tendency to remain in the molten metal in suspension as fine particles."

In a paper entitled "The Solid Non-Metallic Impurities in Steel," the author, Henry D. Hibbard, writes:

> "If other elements have been added, such as Al, W. Cr, Ti, or V, their oxides and silicates may be present.
>
> "The too plentiful use of Al in steel may have been condemned, partly at least, because it forms oxides or silicates in the metal, which, being insoluble and infusible, exist in the solid steel as very harmful sonims. Of course, to form the oxide there must still be some oxide of iron or manganese in the steel. If the metal were free from O perhaps the weakening effect of Al when added in greater quantity than a few hundredths of 1 per cent would not occur. So a part of the Al added in the ladle would form sonims which might be fluxed and floated out, while that added in the molds, if the steel were free from O, would not be oxidized, but would all be left to exercise its full effect in preventing the formation of gas-bubbles and the resulting blow-holes in the steel."

Coating Iron With Aluminum.

The iron article to be coated is first galvanized or tinned, and is then immersed in molten aluminum at about 700 deg. or 800 deg. C., and during the immersion the surface is swept by steel brushes. The tin or zinc passes into the molten aluminum, and aluminum replaces it on the iron surface. The article is treated in this manner in two or more of such baths, and the greater part of the tin or zinc is left in the first bath. It is claimed that this process causes the aluminum to adhere to the surface of the iron so well that it will not come off, nor tarnish, nor corrode under the action of air, water, or heat, and cannot be stripped off by mechanical means.

Melting Points of Firebricks and Clays.

The Bureau of Standards recently determined the melting points of firebricks in an accurate way. The results are interesting as indicating the commercial value, with regard to their heat-resisting properties, of the various kinds of firebricks. The results obtained were:

Fire clay brick	1,555° to 1,725° C.
Bauxite brick	1,565° to 1,785° C.
Silica brick	1,700° to 1,705° C.
Chromite brick	2,050° C.
Chromite brick	2,050° C.
Magnesia brick	2,165° C.
Koalin	1,735° to 1,740° C.
Bauxite	1,820° C.
Bauxite clay	1,705° C.
Chromite	2,180° C.
Pure alumina	2,010° C.
Pure silica	1,750° C.
Carborundum	2,700° C.

The value of 1,750° given for silica is not the true melting point, but represents the temperature at which the silica distinctly flows.

Efficiency of Illuminants.

It is pointed out that beside the efficiency of the illuminant such questions as the distribution of light, intrinsic brilliancy, and color are important. But practically any distribution curve can be obtained by suitable shades and reflectors, etc., although with some loss of light. A bad natural distribution curve is therefore a disadvantage, and so is a high intrinsic brilliancy. In correcting either of these defects a loss of from 10 to 30 per cent may be incurred. Color has a direct influence on efficiency; bluish-green light is probably the most efficient radiation at low illuminations. A diagram is given showing the efficiency in candle-power per watt, plotted against the energy and consumption of various illuminants. The highest figure recorded for the titanium arc and yellow flame-arc is about 5 candle-power per watt.

Obtaining Extra High Temperatures.

A means of obtaining extra high temperatures from an electric arc is described in the "Electrician." The method consists of combining with an ordinary electric arc a jet of air or oxygen or an oxyacetylene or oxyhydrogen flame. The simplest form of the apparatus has a hollow carbon electrode through which a blast of oxygen or air can be blown. The metal plate to be heated forms the positive pole and the carbon electrode the negative. The arc is struck in the ordinary way and operated by a special mechanism with a hand feed. Several other arrangements may be used, some of which have separate pipes serving to project the oxyacetylene or oxyhydrogen flame on to the electric arc. It is stated that the effect of the oxygen burning inside the arc is to produce a temperature greatly in excess of that of the electric arc alone; also a similar effect is obtained when the oxyacetylene or oxyhydrogen flame burns in the same space as the electric arc.

Improving Noisy Gearing.

Machinery states that a simple method of lessening the noise of gearing has been found successful on a large scale in some Petrograd shops. For gears less than 18 inches in diameter two sheets of tin are fitted, one on each side of the wheel, so as to box in the space between the rim and the boss, the sheets being screwed to the rim. This space between the sheets is filled with sawdust and No. 4 shot, to eliminate vibration. When the diameter of the gears is greater than 18 inches, wooden rings are used instead of tin, attached in the same manner. A felt packing is used to prevent the sawdust leaking out. This arrangement not only reduces the amount of noise produced by the gearing, but it also has the advantage of closing the spaces between the spokes of the wheel, and so making it impossible for a workman to get his arms or tools caught in the wheel.

Disposal of Waste Metals.

One unaccustomed to the handling of raw material in large quantities little realizes the amount of work entailed in trying to dispose economically of the immense amount of waste incident to the carrying on of manufacture in a factory so large as the Hawthorn Works of the Western Electric Company. When, however, a monthly raw material input approximating $1,500,000 in value is considered it is not difficult to conceive the amount of waste resulting from its use. A somewhat clearer idea of the amount of material involved may be obtained from the figures representing the aproximate monthly averages of the large items of junk disposed of. Brass, 100 tons; copper, 180 tons (125 tons from the cable, rubber and insulating shops); German silver, 17½ tons; iron and steel 89 tons; solder skimmings, 4 tons; lead, 833 tons. All these materials are carefully separated, cleaned, and baled in the form in which they command the highest price, according to J. M. Bateman, in the Proceedings of the American Institute of Metals.

Rusting of Iron in Water.

Many years ago Crace Calvert concluded that the rusting of iron in water was occasioned by dissolved carbonic acid and oxygen, the former being the predisposing cause, since no action occurred in its absence. These conclusions have since been widely supported. Experiments conducted by W. A. Bradbury, and reported in full in "Chemical News," show that rusting takes place very rapidly in tap-water, while in well boiled tap-water no rusting should occur. During rusting atmospheric oxygen is absorbed. The solution of iron by carbonic acid should result in the production of hydrogen, thus $Fe + 2H_2CO_3 = FeH_2(CO_3)_2 + H_2$, but in experiments with tap-water no gas could be collected after over a week. Water saturated with CO_2 did evolve considerable quantities of gas. These experiments confirm the view that rusting is due to the combined action of oxygen and carbonic acid, and show that the oxygen is utilized in two ways: (a) in the oxidation of the nascent hydrogen liberated, and (b) in the oxidation of the iron bicarbonate to rust. Further tests showed that magnesium chloride solution does not act on iron in the absence of carbonic acid, although it has been stated that such solutions do react with iron, even in the cold, according to the equation—$Fe + MgCl_2 + 2H_2O = Mg(OH)_2 + FeCl_2 + H_2$.

The Texture of Firebrick.

What constitutes a good firebrick is a favorite question, and one which does not admit of a satisfactory answer. The requirements for firebricks vary so widely in different furnaces, or in particular parts of a single furnace, that the ideal firebrick can be defined only in abstract terms, and this the more because some properties can be highly accentuated only at the expense of others.

Texture is one of the most important qualities of a firebrick, since, assuming that the chemical composition and refractoriness are otherwise satisfactory, the life and character of the firebrick are largely determined by its texture. The texture of a refractory may vary from that of the light porous bodies used in making bricks for insulating boilers, etc., to non-porous or vitreous bodies used in making crucibles, acid-resisting bricks for acid towers, etc. There are quite a number of intermediate types. The different types of texture were exhibited. The samples were prepared by cutting the brick transversely, polishing an exposed face, and finally cementing a glass plate on the polished faces by means of hot Canada balsam.

It was shown that the refractoriness of a firebrick under ordinary conditions of measurement is dependent to a small extent on the grain-size. The after-contraction of firebricks and the after-expansion of silica bricks is due to the arresting of the changes which occur during the firing of a brick before they are completed.

For bricks which have to resist the abrasive action of streams of flue dust, coal ashes, slags, etc., a close texture is necessary; but a close-textured brick is liable to split with abrupt variations of temperature. To reduce the tendency to splitting in this way a uniform texture is desirable. The chemical composition of the brick in relation to that of the dust and slag it has to resist at high temperatures is of great importance. Examples illustrating the importance of both texture and chemical composition were shown. In slags which exert a severe action on the firebrick, the importance of small well-fitting joints, cemented by a good jointing clay, was also emphasized, since with bricks having a close uniform texture and the right chemical composition the joints are the weakest places.

Other examples were also given, showing that the texture of a firebrick is as important as chemical composition and refractoriness. The texture is a property which can be largely controlled by the manufacturer, whereas the other qualities are not so amenable to treatment. It was shown, by using the blast furnace as an illustrative example, that the consumer must carefully consider the conditions which prevail in different parts of any particular furnace before he selects for trial particular types of textures as likely to suit particular parts of his furnace.

The above is abstracted from a paper by Dr. J. W. Mellor before the Faraday Society, London, held on November 8, 1916.

INDUSTRIAL SAFETY

THE FOREMAN'S PART IN "SAFETY FIRST"

There are three good reasons why a factory foreman should participate in safety work earnestly and actively:

1.—Because of its humanitarianism. "There is," according to Ida Tarbell, "nothing so valuable as the man. The stronger, the longer-lived, the happier, the more ambitious he is, the better for mankind. Injury and death are the fruits of ignorance, recklessness and greed. A death toll is no part of a properly managed industry."

Loss of life and limb are not humanitarian by-products of industry. Nothing is so precious as a perfect body and health. The foreman should realize that the bodies and health of his men are of much more importance than the machinery they operate; that the flesh and blood of the "boys" is worth more than the castings and steel they handle. The foreman is in a special sense "his brother's keeper." He is placed not only to look after the upkeep and care of machine tools, but, in all better plants, also to guard the welfare of his human tools. A broken shaft or defective casting can be replaced, but a leg or arm, an eye or a life lost is lost forever, and no compensation ever fully compensates. Just as a father looks after the welfare of his dependents, so should department heads look after those in their charge. Let your "boys" realize that you are their "old man"; that the "old man" is genuinely interested in their welfare and is looking after them for their own good, and the foreman's task has been made much easier, and a long step taken toward improving the quality of the factory organization.

Among the many splendid ideas worked out by the late Frederick Taylor we especially like his stand that a foreman should be a teacher rather than a driver, at all time ready to show his men how to properly perform their tasks. It is the business of every foreman to accept raw materials and turn out a finished product. Just so; department heads have to accept the raw material in labor, and are expected to develop the finished labor product, a competent, careful workman. The foreman has no certain means of knowing when he puts a new man to work if he is efficient or careless and a menace to his fellow workers. It is, however, expected of every foreman to take such a man in hand and teach him not only the technical side of his task, but also that carelessness will not be tolerated any more than defective output. Foremen should always remember that they are directly responsible for the recklessness of their men.

2.—Because of its broad economy. We know that several hundred million dollars is wasted in this country annually by preventable accidents. That loss eventually comes out of the ultimate consumers, you and me. This cost is reflected in the price we pay for beefsteaks, groceries and clothing, for out motor cars and gasoline. No one can less afford this than those who, through thoughtlessness and carelessness, bring it upon themselves, the workmen. A thrifty man hates waste. To destroy a man's earning capacity by robbing him of his sight or his limbs is the worst possible kind of waste.

3.—Because it is a good thing for the foreman and his employer. From a strictly business standpoint safety work pays. The efficient and intelligent foreman is measured not only by his ability to produce work satisfactorily as to quality and cost, but also by his ability to build up an organization and eliminate accidents. The foreman is, therefore, financially interested. It is just as important to the employer to reduce accident costs as it is to reduce costs along any other line. We would go even further and say thta it is more important to the employer to reduce accident costs than along other lines. The dollar saved through accident prevention is infinitely more valuable to the employer than the dollar made through sales. And a dollar lost through preventable accidents is doubly dear.

The reduction of accidents lowers the employers' insurance rate, but how much more valuable is the increased good-will, the family spirit, the coöperation, the efficiency that follows where a consistent policy of carefulness toward one another is maintained. Safety work pays.

We believe Rudyard Kipling points out how this is best achieved:

"It ain't the guns nor armament, nor the funds that they
can pay,
But the close coöperation that makes them win the day.
It ain't the individual, nor the army as a whole,
But the everlastin' team work of every bloomin' soul."

INFLUENCE OF HOURS ON OUTPUT.

Memorandum No. 12, issued by the Canadian Committee of the Ministry of Munitions on the health of munition workers, contains a report by Dr. H. M. Vernon, on the relation between output and hours of work. Experiments covering a considerable period fully justify the recommendation previously made by the committee that the hours of work should not exceed 65-67 hours for men and 60 hours for women; in many cases even a smaller number of hours per week would give the best results. Some striking examples of the effect of continued fatigue in diminishing output are recorded. Thus, in the case of some youths of 14-17 years, working on steel base plugs, a rise of 16 per cent in hourly output took place after the Christmas holidays, and subsequently when the hours of labor were reduced from 70.3 to 57.0 an increase in total output of about 19 per cent was reached. These and other results, remarks The Electrician, show that it is possible to be engaged for longer hour and yet do less work.

MEANS FOR REDUCING FATIGUE.

Shorter working hours.

Rest periods during the working day.

Eliminating needless motions.

Showing the relation between fatigue and activity.

Interest the employe in his work.

Time and motion studies.

Arm chairs and chairs with real arms especially fitted to the individual worker. These will be more efficient if provided with footrests.

Let the worker sit down whenever possible.

Welfare or betterment work.

See that there is enough light for the worker and that it is properly distributed.

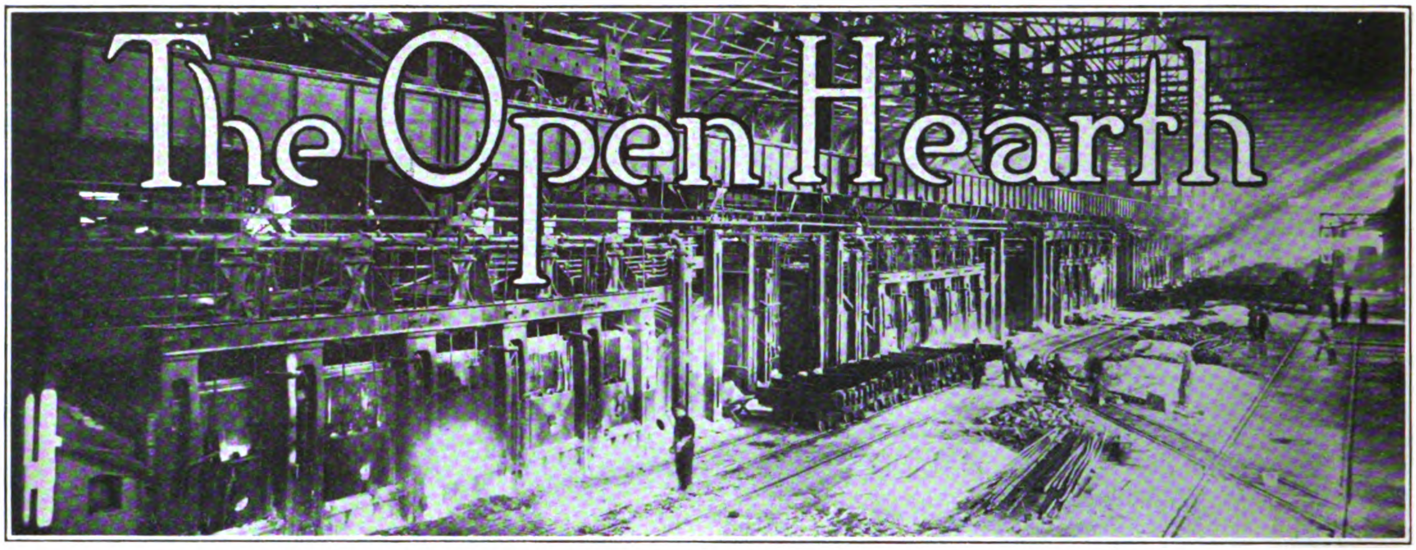
Plenty of ventilation is essential.

Crowded working conditions make for fatigue, avoid clutter, which causes confusion, useless motions and wastes mental energy.

See that the work bench and chairs are at the proper height.

Use gravity and mechanical means wherever possible in placing of materials and working equipment.

Suitable clothing is important.



The Open Hearth

Clarence S. Arms becomes superintendent of the Wright Wire Company's plant at Palmer, Mass., succeeding John S. Loren, resigned.

√ √

W. A. Barrows, Jr., formerly with the Northern Pacific Railway Company in their mineral lands department with office at Brainerd, Minn., is now President of The Thomas Iron Company at Hokendauqua, Pa. He was for many years in the Shenango and Mahoning valleys serving as chemist and superintendent of blast furnaces at Sharpsville, Pa., and Youngstown, O.,—from 1900 to 1908 general manager The Shenango Furnace Company at Sharpsville, Pa. Assumed presidency The Thomas Iron Company, September 1, 1916.

√ √

T. J. Bittner is now superintendent of the 14- and 35-inch mills of the Steelton plant, Bethlehem Steel Company, Steelton, Pa.

√ √

A. J. Boal, formerly with the Midvale Steel Company and the Enterprise Manufacturing Company, Philadelphia, is now general superintendent of the Hoopes & Townsend Company, Philadelphia.

√ √

Benjamin E. Bosler is now superintendent of the mechanical department for the Cambria Steel Company, Johnstown, Pa. He was formerly assistant superintendent of shops there.

√ √

John Penn Brock, who has been vice president in charge of operating departments of the American Iron & Steel Manufacturing Company, Lebanon, Pa., will remain as superintendent of the plants at Lebanon and Reading, for the Bethlehem Steel Corporation.

√ √

R. A. Bull, announcement of whose resignation as manager of production for the Commonwealth Steel Company was carried in these columns in the November **The Blast Furnace and Steel Plant,** on February first will become vice president and general manager of the Chicago Steel Foundry, Chicago, Ill.

√ √

A. A. Burke is assistant superintendent of the slab and rail and structural mills at the Steelton, Pa., plant of the Bethlehem Steel Company.

√ √

James Cavanaugh is assistant chief electrician for the Inland Steel Company, Indiana Harbor, Ind.

Edward T. Corbus, production manager of the Union Drawn Steel Company, Beaver Falls, Pa., has resigned, effective January 1, and will be connected with the Columbia Steel Shafting Company, Carnegie, Pa., after that date.

√ √

S. C. Cozad, formerly connected with the building of the open hearth department of the Youngstown Iron & Steel Company, Lowellville, Ohio, is now field engineer on the construction of the projected open hearth of the Trumbull Steel Company, Warren, Ohio.

√ √

Meyer Davis, formerly chief engineer for the Asbestos Protected Metal Company, Pittsburgh, Pa., has been made manager of the San Francisco office of the company, with headquarters in the Hobart building.

√ √

Francis D. Dutton, superintendent of the Lebanon furnaces of the Bethlehem Steel Corporation, also assumes charge of the new furnaces just acquired at that point from the Lackawanna Iron & Steel Company.

√ √

C. W. Forcier is now purchasing agent for Mackintosh, Hemphill & Company, Pittsburgh. He was formerly storekeeper for the Pittsburgh Railways Company.

√ √

D. B. Gehly, secretary and treasurer of the Cambria Steel Company, and secretary of the Midvale Steel & Ordnance Company, has been made secretary of the Midvale Steel Company, Worth Brothers Company and the Wilmington Steel Company, vice D. M. Deemer, resigned. He has also been made treasurer of the same companies, vice W. C. MacFarland, resigned.

√ √

Fred Hendron, for some time connected with the operating organization of the Inland Steel Company, Indiana Harbor, Ind., has been given the position of roller on the 40-inch mill which is part of the rolling equipment of the new blooming and structural mill.

√ √

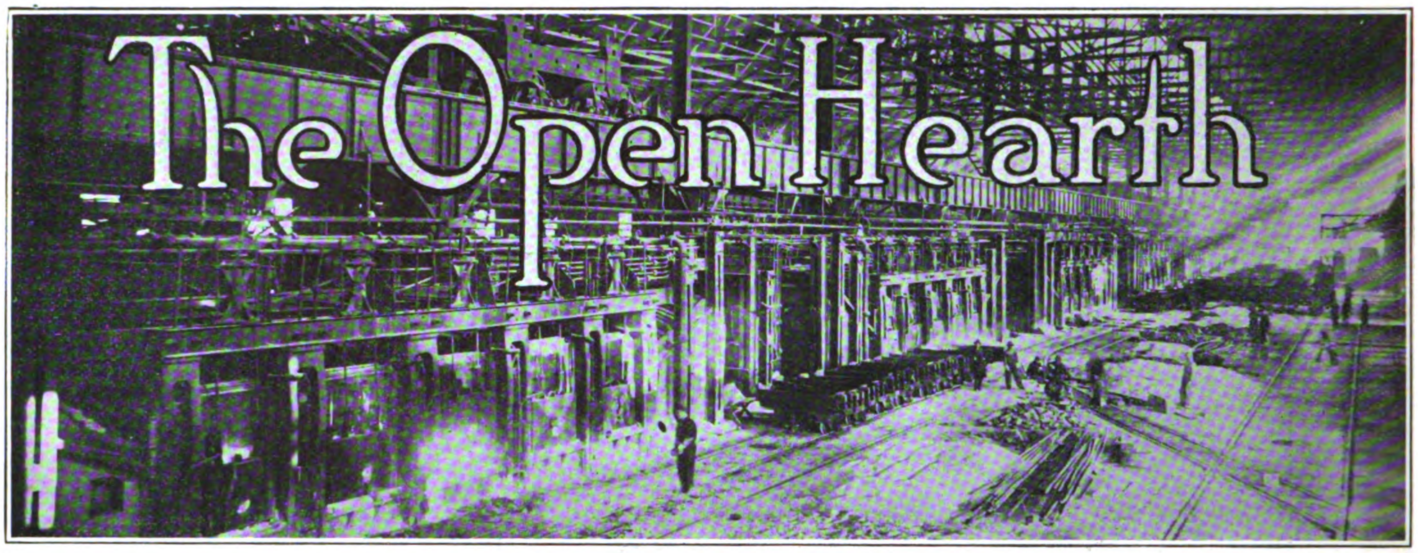
James Johnson has been promoted to the position of roller, 40-inch mills, at the new blooming and structural plant of the Inland Steel Company, Indiana Harbor, Ind.

√ √

M. R. Jonas is now test engineer for the By-Product Coke department of the River Furnace Company, Cleveland, Ohio.

√ √

Frank Kelly, formerly in charge of the slab mill, Steel-



ton plant, Bethlehem Steel Company, has been made superintendent of the rail and structural mill.

V V

Theodore Knowles, who has been with the Inland Steel Company for several years in the rolling mill department, has been promoted to the position of roller on the new 32-inch mills recently installed in the blooming and structural mill at the Indiana Harbor plant.

V V

Frank B. Lounsberry has resigned his position as assistant metallurgist for the Halcomb Steel Company, Syracuse, N. Y., to become metallurgist for the Atlas Crucible Steel Company, Dunkirk, N. Y.

V V

Thomas McKenney, assistant supervisor of labor and safety, South Works, Illinois Steel Company, South Chicago, Ill., has been made supervisor, vice A. H. Young, resigned.

V V

A Brice Moore, who formerly was connected with John J. Caine, steel broker, New York City, has become manager of the United American Iron & Steel Company, Albany, N. Y.

V V

R. C. Parsons has been made superintendent of the rail, structural and slab mills of the Bethlehem Steel Company, at Steelton, Pa.

V V

Dan Philip is roller on the new 28-inch mills of the blooming and structural mill of the Inland Steel Company, Indiana Harbor, Ind.

V V

Frank Powers is now in charge of the reheating furnaces for the Minnesota Steel Company, Duluth, Minn., having resigned his work with the Interstate Iron & Steel Company at East Chicago, Ind., as heater to take up his new duties.

V V

Charles G. Sanford has resigned as treasurer of the American Tube & Stamping Company, Bridgeport, Conn.

V V

David Saunders, who has been connected with the Indiana Steel Company in various capacities for the past twelve years, has been made superintendent of the new blooming and structural mill at the Indiana Harbor plant.

V V

George L. Shook, who recently assumed charge of the blast furnace department of the Central Iron & Steel Company, Harrisburg, Pa., was formerly with the Northern Iron Company, Port Henry, N. Y.

A. L. Sonnhalter, who has been chief chemist and metallurgist for the Page Woven Wire Fence Company, Monessen, Pa., for the past year, has resigned to become assistant superintendent of the open hearth department of the United Alloy Steel Corporation, Canton, Ohio.

V V

Ralph H. Sweetser is engaged in consulting work in connection with pig iron production, with offices and headquarters at Easton, Pa.

V V

W. Lee Tanner is now chief chemist at the explosive plant of the Bethlehem Steel Corporation, New Castle, Del.

V V

Cylde E. Tousley is now manager of the service deparment of the Trumbull Steel Company, Warren, Ohio, succeeding J. F. Bonnell. He was formerly in the sales department of the company.

V V

L. A. Wanamaker is now superintendent of warehouses for the new blooming and structural mills of the Inland Steel Company, Indiana Harbor, Ind. He was formerly bar mill warehouseman for the same company.

V V

Eli Webb, who resigned his position as blast furnace superintendent for the Pittsburgh Crucible Steel Company December 1, is now general superintendent for the blast furnaces of the Virginia Iron, Coal & Coke Company, with headquarters at Roanoke, Va.

V V

L. C. Weirich, formerly blooming mill roller for the Inland Steel Company, Indiana Harbor, Ind., has been promoted to the position of assistant superintendent of the new blooming and structural mills.

V V

A. H. Young, supervisor of labor and safety at the South Works of the Illinois Steel Company, South Chicago, Ill., on January 1, 1917, moves to 14-18 West Twenty-fourth street, New York City, as director of the American Museum of Safety, succeeding Dr. E. H. Tolman.

BACK NUMBERS "THE BLAST FURNACE AND STEEL PLANT," WANTED.

On account of a shortage in the files of THE BLAST FURNACE AND STEEL PLANT for October and November, 1916, and because copies of these issues are wanted by some subscribers, a premium will be paid for copies of either or both of these issues returned to Box 65, Pittsburgh, Pa. An extra premium of 50 cents will be paid for June, 1915, Nos.

Some Pointers on By-Product Coke Oven Operations

Concluded from this page last month.

The by-product apparatus which cools the gas and extracts from it tar and ammona does not extract in any important degree the light oil vapors or so-called "benzols." (Although the terms "benzene" and "toluene" are, in English and American scientific usage, the correct names for the hydrocarbons C_6H_6 and C_7H_8, commercial usage in both England and America has adopted the terms "benzol" and "toluol" based and European continental practice, meaning either the crude or purified grades of the substances. In this paper for the sake of simplicity the termination "ol" is used exclusively for these hydrocarbons whether of pure or commercial grade.) Owing to their vapor tension and the relatively large volume of the coke oven gas these substances pass on as vapors in the gas, of which they make up about 1 per cent by volume, and are extracted only when the gas is scrubbed by a "wash oil" having absorbent or solvent properties with respect to these vapors. Of the total light oil recovered from the carbonization of the coal 95 per cent results from scrubbing the gas, and only 5 per cent is found in the tar.

The gas after leaving the ammonia saturators passes through a cooling tower so as to be brought to a temperature suitable for thorough extraction of the benzols. From the cooler it passes to the scrubber and therein comes into intimate contact with the wash oil which absorbs the benzols.

The wash oil is taken from storage tanks and pumped successively over the benzol washers in a direction opposite to that of the gas. In this manner the cool, fresh wash oil containing no benzol enters the scrubber at the point where the gas, nearly exhausted of benzol vapors, is leaving and thus absorbs practically the last remaining traces of these vapors. By even distribution of the wash oil over a large area in the washer, the maximum surface of oil is exposed to contact with the gas. Enriched with the benzols, the wash oil is delivered to a tank, and then pumped to the benzol recovery plant where it is distilled with steam to drive out the absorbed benzols.

In the United States there is generally used for wash oil a petroleum product of specific gravity about 0.88 at 15 deg. C.,) which flows readily at 4 deg. C., and of which about 90 per cent distils between 210 and 370 deg. C. In Europe the wash oil is commonly a tar oil, one of the middle or heavy fractions from tar distillation of which 90 per cent distils between 200 and 300 deg. C., and the naphthalene content is not over 7 per cent.

Before entering the still the enriched wash oil is preheated by heat exchangers utilizing the latent heat of the vapors from the still and the sensible heat of the spent wash oil.

After the heat exchangers the enriched oil passes through a superheater in which it is heated to a higher degree by steam coils. From the superheater it passes into the still where it is distilled by direct steam and all of the benzols—together with naphthalene—are driven off.

The hot wash oil, freed from benzol and its homologues and from naphthalene and water, leaves the still to enter the heat exchanger above mentioned, where a part of its heat is transferred to the enriched wash oil. It is then delivered to the wash oil coolers, brought to a temperature of about 25 deg. C. by running water and delivered to a tank from which the circulating pumps take it again to the washers.

The light oil produced by the distillation of the wash oil is a mixture of benzol, tuluol, xylol and solvent naphtha, with small amounts of wash oil and naphthalene. This is again distilled in order to separate it into various fractions. After the benzol, tuluol, xylol and solvent naphtha have been distilled off, a certain amount of wash oil and naphthalene remains in the still tank and from this residue the naphthalene is usually recovered by cooling. The presence of wash oil in the light oil is due not only to mechanical trapping of the heavy oil during distillation, but also to its own actual distillation by the aid of the direct steam used.

The products recovered from 1,000 gals. of light oil vary according to the kind of coal coked and the method of operation of the light oil plant. In many plants where the lighter vapors are not fully recovered, the results are less advantageous, but under the Koppers recovery system, it is stated, the yields average about as follows:

Yield from 1,000 Gals. Crude Light Oil.

	Gals.
Crude benzol	690
Crude xylol	40
Crude xylol	40
Solvent naphtha	45
Wash oil residue with naphthalene	75

The wash oil remaining from the fractionation of the light oil is drained into cooling pans, where the naphthalene is crystallized out, the wash oil being then drained off and returned for circulation through the system. In large plants where the amount of naphthalene is considerable a centrifugal dryer is employed to centrifuge the naphthalene in order to remove the remaining small amount of oil. Naphthalene so obtained is either sold as crude naphthalene or may be added to the tar produced in the coke plant.

To produce pure products, crude fractions from the light oil still must be further purified and redistilled. For purification the crude benzols are first washed with sulphuric acid and then with caustic soda and water separately. The acid takes out certain unsaturated compounds, chiefly hydrocarbons (olefines) and phenols, from the benzols. Most of these impurities form with the acid thick resinous substances insoluble in benzol, which, on account of their high specific gravity, settle out. The used acid is drained into small tanks and may be regenerated or otherwise disposed of. The benzol is then treated with a solution of caustic soda to neutralize any remaining acid and finally washed with water. A part of the resinous bodies, the polymerized olefines, dissolves in the benzol giving it a brown color which necessitates redistillation in order to produce a colorless or water white benzol.

Where it is not desired to obtain products of exact boiling points the redistillation of the washed benzol is carried out simply to separate the benzol from the resinous substances held in solution, and little attention is paid to exact regulation of the boiling points. This distillation is very quickly accomplished and the benzols so produced are termed "purified benzols," having practically the same boiling points as the crude benzols.

When the demand is for pure benzols of rigid require-

(Concluded on Page 50)

NEWS OF THE PLANTS

The Philadelphia Section, Association of Iron & Steel Electrical Engineers, will hold its January meeting on Saturday, January 6, at the Majestic Hotel, Philadelphia, beginning with a dinner at 6:00 p. m. Will J. Davis, Jr., president of the American Flood Lighting Company, Chicago, Ill., will talk on the subject "Industrial Flood Lighting, Its Origination and Application," illustrating the talk with lantern slides showing the flood lighting of Niagara Falls. The paper will begin promptly at 8:00.

The Youngstown Chemists' Club has been recently organized at Youngstown, Ohio, the first meeting being held on December 14, 1916. The following officers were elected:

President, Edwin G. Pierce, consulting chemist.
Secretary, Carl W. Weesner, Carnegie Steel Company.
Treasurer, H. E. Moyer, Brier Hill Steel Company.

Shipment of the material for the new battery of 50 Wilputte by-product coke ovens, to be erected by Mitsubishi Goshi Kaisha, at Kenjiho, Korea, is rapidly being completed by the contractors, Otto Coking Company, Inc., New York. The new ovens will furnish the coke for the blast furnace plant now being erected for the Mitsubishi Company, at Kenjiho.

The American Steel & Wire Company, Donora Steel Works, Donora, Pa., has awarded contract for pulverized coal equipment in connection with eight 60-ton open hearth furnaces to the Fuller Engineering Company, Allentown, Pa.

The Bethlehem Steel Corporation is installing pulverized coal equipment at two open hearth furnaces in the Number One Lehigh plant at South Bethlehem, Pa. The Fuller Engineering Company is installing the equipment.

John W. Hubbard, president of Hubbard & Company, and the National Nut & Bolt Company, both of Pittsburgh, has bought controlling interest in the Standard Engineering Company, Ellwood City, Pa. Large additions will be made to the plant, which is at present turning out a line of tube-mill machinery, rolling-mill equipment, and allied lines, together with a full line of castings. After January 1 a reorganization will be made, with the new owner as president.

The January meeting of the Pittsburgh section, Association of Iron & Steel Electrical Engineers will be held on January 20, at the Fort Pitt hotel, the papers being preceded by a dinner a 6:00 p. m. Papers will be read by H. D. James, Westinghouse Electric & Manufacturing Company; Frank Smith, Otis Elevator Company; R. H. McLain, General Electric Company, and F. J. Burd, Cutler-Hammer Manufacturing Company; all dealing with direct- and alternating-current automatic skip and bell hoists. The new officers will have charge of this meeting.

Coke will be produced at the new plant of the Seaboard By-product Coke Company at Jersey City, N. J., early this year, estimating from the present stage of the construction work. By first erecting only temporary steel sheds to cover the 110 ovens while under construction, the H. Koppers Company, Pittsburgh, which started work May 1, 1916, has been able to bring the ovens rapidly toward completion. The by-product building, boiler house, quenching track, purifiers and coal and coke-handling apparatus have been started in the order named. The benzol plant will be the last department to be built on account of the pressing demand for coke.

Semi-official announcement has been made that the Cambria Steel Company will build a car wheel plant in Johnstown, involving an expenditure of $2,000,000 or more. Difficulty in buying sufficient wheels to supply its own steel car plant brought the project into consideration months ago, and much discussion has resulted, with one intimation that the plant might go to Coatesville, Pa.

The Otto Coking Company, Inc., New York, has received a contract for the erection of 60 Wilputte by-product coke ovens at the plant of the Woodward Iron Company, Woodward, Alabama. The new ovens will have a capacity of 13 net tons of coal, and will operate on an 18-hour coking time. Work is being rushed on the construction, and the new battery is scheduled to start operation about July, 1917.

The sale of the Superior Steel Company plant at Carnegie, Pa., to a group of Philadelphia and New York bankers was recently consummated. The price paid was $11,500,000, $6,000,000 in cash and the balance in stock of the new organization, the Superior Steel Corporation, chartered under the laws of Virginia. The management of the new corporation will remain for the present in the hands of the men who have formerly handled the affairs of the Superior Steel Company. The Carnegie plant manufactures hot and cold rolled strip steel for hardware, automobiles and metal furniture. It has a capacity of 115,000 tons a year.

Every employe of the H. W. Johns-Manville Company who had been with the company a year or more was gladdened by the receipt of a Christmas Greeting signed by President T. F. Manville announcing the Board of Directors' decision to give a bonus equal to 10 per cent of the year's salary. This action was prompted by the very satisfactory earnings of the Company in 1916 and the splendid service rendered by the J-M employes.

SILENT CHAIN DRIVES FOR STEEL MILLS.

Silent chain drives for steel mill machinery offer advantages over direct engine drives and gear drives. They are essential in electrifying an existing plant, employing customary drives, for the change to motor drives through silent chain can be made with little, if any, change in the driven machine.

Link-Belt silent chain drives, contrasted with gear drives, offer great flexibility of installation and operation. The absolute alignment of shafts and gears is not required, nor are self-contained bases necessary. The work of power transmission is more evenly distributed in silent chain drive, for more than half of the sprocket teeth are engaged, instead of but a few, as in gear drive.

Silent chain drives possess advantages over direct motor connection. They permit the use of standard speed motors, as a general rule, instead of the slow speed machine required by direct connection. A wide range of speed ratios is available to users of Link-Belt Silent Chain, thus simplifying the selection and application of the motor.

RECENT PATENTS

The following patents are reported expressly for THE BLAST FURNACE AND STEEL PLANT by E. G. Siggers, patent attorney, Suite No. 31, N. U. building, Washington, D. C., from whom copies of any one of the patents may be obtained by sending fifteen cents in stamps.

Herman Bussel, El Paso, Texas, has invented improvements in metal-bending machine, No. 1,208,091, dated December 12, 1916. This invention relates to an improved metal bending and shearing machine, and has for its primary object to provide a simple and easily operated mechanism whereby a metal bar may be readily bent to any desired angle. It comprises a base, spaced rotatable posts removably mounted upon said base, each of said posts having a longitudinal slot opening upon the upper end of the post into which a metal bar is adapted to be fitted, the other of the posts constituting a bearing for the bar, and a detachable leaver adapted to be interchangeably engaged on the upper ends of said posts to rotate the post within which the bar is fitted and angularly bend the bar.

Samuel Trood, of New Castle, Pa., has invented improvements in machine for separating metal sheets, No. 1,207,668, dated December 5, 1916, and he has assigned the same to the Industrial Development Company, of New Castle, Pa., a corporation of Pennsylvania. This invention relates to metal plants or sheets, and it has particular reference to means whereby piles or stacks of metal plates, which have become somewhat cemented together or attached to each other in various ways, may be quickly and conveniently separated without damaging the metal. The machine comprises a frame, supporting a resilient hammer member, driving members for moving the sheets in contact with the hammer member and guides for automatically adjusting the position of the hammer member.

Clinton De Witt Wagner, Cedar Rapids, Iowa, has invented improvements in sheet metal turning machine, No. 1,207,349, dated December 5, 1916. This invention relates to machines used by tinsmiths and others for turning beads and narrow flanges in sheet metal, and the object of the invention is to provide such an improvement in the rolls and machine as will admit of the formation in a single operation and at one setting of the machine, of beads suitable for adjustable pipe-elbows and the like. It consists of a pair of beading rolls the female roll having a rectangular peripheral groove, and the male roll having an inclined edge, and mandrels carrying said rolls, one of the mandrels having an unobstructed endwise movement.

The following patents are reported expressly for THE BLAST FURNACE AND STEEL PLANT from the Patent Law offices of Norman T. Whitaker, Legal Building, Washington, D. C., (opposite U. S. Patent Office), from whom copies of any one of the patents may be obtained by sending fifteen cents in stamps.

Patent No. 1,207,881 on a Process of Smelting Metallic Ores has been granted to Henry L. Doherty, of New York, N. Y. What the inventor claims as new is substantially as follows: The process which comprises superheating said ore with an oxidizing flame, the said oxidizing flame burning with the aid of superheated air and being in direct and intimate contact with said ores, continuously adding a reducing material to said superheated ore, and subjecting the mixture of ore and reducing material to the action of radiated heat from a reducing flame of carbonaceous material in aerial suspension burning with a limited amount of heated air to assist in the reduction of the metal of said mixture and to maintain the said mixture at a temperature sufficient to smelt reduced metal during the said reduction.

A process of treating Ferrotungsten has been patented by Philip M. McKenna, Washington, D. C., which is patented as No. 1,208.59 . Patentee claims as follows: A process of treating smelted ferro-tungsten alloy for the removal of metalloid impurities, which consists in comminuting the smelted mass, then subjecting the comminuted material to the action of an acid which will combine with the impurities in the production of hydrogen compounds and which will not combine with the metallic alloy.

A patent on a Method of Seperating Fumable Metals by Fractional Distillation has been issued to John Thomson, of New York, N. Y., which includes the following: The method of separating alloyed metals, each having a different vaporizing point, which consists in first fuming the metal which vaporizes at the lower temperature and then causing the residium to flow into another contiguous basin where it is acted upon and vaporized by a higher temperature. The number of this patent is 1,208,237 and has been assigned to the John Thomson Press Company, Jersey City, N. J., a corporation of New Jersey.

Edward Fulton Law of Manchester, and Christer Peter Sandberg, of Westminster, London, have just patented an apparatus for casting steel, the claims are substantially as follows: In apparatus for casting steel, the combination of a mold, a source of electricity, a loose contact device situated close above the mold base and connected to one pole of the source of electricity and an electrode above the mold connected to the other pole thereof. The number of this patent is 1,207,572 and they have assigned one-third to Sir W. G. Armstrong, Whitworth and Company, Limited, Newcastle-upon-Tyne, England.

Radclyffe Furness, of Jenkinstown and Richard H. Patch. of Philadelphia, Pa., have secured two patents No. 1,206,833 and No. 1,206,834 on a High Speed Tool-Alloy. The first patent claims chromium, molybdenum between four and eleven per cent and cobalt; and a high speed tool steel containing the following ingredients in the proportion specified: chromium 2.5 to 5 per cent molybdenum 4 to 11 per cent and cobalt 2 to 20 per cent; and a high speed tool steel containing the following ingredients in the proportions specified: carbon less than one per cent, chromium 2.5 to 5 per cent, molybdenum 4 to 11 per cent, and cobalt 2 to 20 per cent; and a high speed tool steel containing the following ingredients in approximately the proportions specified: carbon less than one per cent, chromium about 4 per cent, molybdenum about 8 per cent, and cobalt about 5 per cent; second patent claims a high speed tool steel containing chronium 2 to 6 per cent, tungsten 9 to 15 per cent, and cobalt 5 to 20 per cent, and a high speed tool steel containing from 2 to 6 per cent chromium, less than 15 per cent of tungsten, and not less than 10 per cobalt.

Some Pointers in By-Product Coke Oven Operation.

(Concluded from Page 46.)

ments a careful fractionation is made by the use of a highly efficient rectifying column and dephlegmator. It is possible to produce finished benzols of such narrow limits of boiling points that they approach in this respect very closely the absolutely pure substances. At one Koppers benzol plant in the United States both benzol and toluol have been produced commercially of so high a grade that 100 per cent distilled within 1.0 deg. C. this range including the true boiling point of the pure substance, and 95 per cent of the product distilled within a range of 0.5 deg. C. This extraordinary degree of purity is of large advantage to manufacturers of explosives and chemicals.

In the fractional distillation of a mixture of liquids, such as crude benzol, it is essential that the dephlemator be so constructed that all the vapors passing through it are cooled to a uniform temperature. Otherwise the separation of the different vapors is incomplete and uncertain.

Furthermore, it is of great importance to have the vapors rise in the dephlegmator in such a way that the mist of heavier condensed vapors may have opportunity to fall behind. If this principle is neglected, as in some types of dephlegmator, the mists of heavier constituents gather in such a position that they are mechanically carried into the condenser with the light vapors. Stills for continuous fractionation and selective condensation have been suggested for crude benzols, but have not yet proven satisfactory.

Steel Plant Incorporations and Construction

Canton, Ohio. — The Canton Sheet Steel Company will build an open-hearth plant to supply its own needs for sheet bars. The plans at present call for three furnaces, of 50-tons nominal capacity, and a combined continuous blooming mill and sheet-bar mill. The annual capacity will be about 100,000 tons against a present bar consumption of 90,000 tons.

Glassmere, Pa.—The Acme Steel Company has been formed and has secured a site here for erecting a crucible steel plant, to consist at first of a three hole six-pot furnace with the requisite heating furnaces and a ten-inch bar mill. Electric drive will be used throughout. Two hammers, 1500-hundred and 700-hundred pounds respectively, will be installed, together with annealing equipment and shears, including an alligator shear for cutting up stock for the pots. Work will be begun soon after the middle of January, bids being received about that date by F. Denk, consulting engineer, House building, Pittsburgh.

Canton, Ohio—The United Alloy Steel Corporation has plans for the erection of a combination 12- and 14-inch mill for rolling merchant bars. It is understood that the site of this plant is still undecided, a local site and one in Detroit, Mich., being considered.

Bristol, Tenn. — Apparently well-authenticated reports state that the Bristol blast furnace and the Crescent rolling mill, both of which have been closed down since 1908, have been sold by the Virginia Iron, Coal & Coke Company, Roanoke, Va. It is understood that the purchasers will immediately repair and improve the equipment and begin production as soon as possible.

Spring City, Pa.—The E. P. Leaf Company, Philadelphia, principal holder of the Spring City Bloom Works, has sold out to the Parkesburg Iron Company, Parkesburg, Pa., which will remodel the plant and overhaul it with a view to putting it into commission at an early date. The plant consists of eight forge fires, and all will be used in making charcoal iron blooms for the buying plant.

Massillon, Ohio — The Central Steel Company has had work begun on two additional 75-ton open hearth furnaces, which, when completed, will bring the total up to seven.

Wheeling, W. Va. — The Whitaker-Glessner Company plans to build a sheet mill, to consist of eight hot stands and accompanying cold roll stands, at Beach Bottom. Contracts for the buildings have been awarded to the McClintic-Marshall Company, for the mills and other equipment to the Wheeling Electric & Manufacturing Company. Work will be begun at once, in the hope of beginning production next fall.

Sparrows Point, Md.—The Bethlehem Steel Company is inquiring for cranes for the Maryland Steel Company's plant here, and expects to cover for its needs within the next few days.

Newark, N. J.—Igoe Brothers, manufacturers of wire and wire nails, have plans for an addition 50 x 90 feet in extent, to be built at a cost of $3,500 on a site at Avenue A and Poiner street.

Trenton, N. J.—The Jon A. Roebling's Sons Company is planning for the early erection of a new wire plant, to replace the one burned about twelve months ago. Special machinery is being prepared for the new quarters.

Bethlehem, Pa.—Contract for construction of new buildings for the Bethlehem Steel Company, at Sparrows Point, Md., including a gas-driven engine generating house and a gas-blower engine house has been awarded the Irwin & Leighton Company, 126 North Twelfth street, Philadelphia. The improvements will cost about $900,000.

Detroit, Mich. — The Williams Iron Company has been incorporated here with a capital stock of $300,000 to refine, smelt and manufacture metals, ores and minerals. Harry E. Williams, Jean M. Williams and Thomas I. Cochran are listed as principal stockholders.

Birmingham, Ala.—The Republic Iron & Steel Company plans to spend $500,000 in improving the furnace plant at Thomas, Ala., and the coal mines at Palos, Ala. Work will be begun shortly on the changes.

Duluth, Minn. — The Hikawa Iron Company has been formed by Thomas A. Walker, Alexander Hamfield, Frank Crassweller and W. A. and W. P. Hicken, with a capital of $200,000.

Slatington, Pa. — The recently incorporated Slatington Iron & Steel Company, taking over the Slatington Rolling Mills, has increased its capital stock from $10,000 to $100,000. B. Frank Conner is general manager under the new regime.

Birmingham, Ala. — The Gulf States Steel Company will supply coke to the Attalla, Ala., furnace which it recently leased, from its by-product opens now under construction at Alabama City, Ala. These will probably be completed by Aprial 1. 1917. Meanwhile Attalla furnace will be relined and repaired.

IRON AND STEEL QUOTATIONS

COMPARED WITH PRICES OF A MONTH AGO

PIG IRON.

Pittsburgh*—	**November 24**	**December 27**
Bessemer	30.95	35.95
Basic	26.45	30.95@ 31.95
No. 2 foundry ...	26.95@ 27.95	31.95@ 32.95
Malleable	28.95	30.95
Gray forge	26.95	29.95
Ferro-silicon, 50%.	98.00@100.00	98.00@100.00
Ferro-silicon, 10%.	33.00	40.00@ 42.00
Ferro-mang., 80%..	162.00@164.00	160.00@165.00
Spiegeleisen, 20%..	50.00@ 55.00	50.00@ 55.00

* Pig iron prices quoted here are at Pittsburgh, with freight rate from Valleys to Pittsburgh, 95 cents added.

Virginia Furnaces—		
Basic	23.25@ 24.25	27.25
No. 2X	24.00	26.75@ 27.75
No. 2 plain	23.75	26.50@ 27.50
Gray forge	21.25@ 22.25	25.50@ 26.00
Birmingham—		
No. 2 foundry	21.00@ 23.00	24.00@ 25.00
No. 3 foundry	20.50@ 22.50	23.50@ 24.50
Gray forge	20.00@ 22.00	23.00@ 24.00
Philadelphia (del.)—		
No. 2X foundry ..	25.50@ 26.50	29.50@ 30.50
No. 2 plain	25.00@ 26.00	29.00@ 30.00
Basic	26.00@ 27.00	30.00
Gray forge	24.00@ 25.00	28.25@ 28.75
Chicago (at fur.)—		
No. 2 foundry ...	27.00	30.00
Malleable	27.00	30.00
Basic	27.00	30.00
Cincinnati (del.)—		
Northern No. 2 fdy	27.26	31.26
Basic	27.26	31.26
Nor. malleable ...	27.26	31.26
STEEL.		
Tons of 2,240 lbs., at Pittsburgh.		
Bessemer billets ..	52.50@ 57.50	60.00@ 65.00
Open hearth billets	52.50@ 57.50	60.00@ 65.00
Forging billets ...	78.00	80 00@ 85.00
Sheet and tin bars	52.50@ 57.50	60.00@ 65.00
Wire rods	65.00@ 70.00	70.00@ 75.00
FINIESHED PRODUCT.		
Tons of 2,000 lbs., at Pittsburgh.		
Skelp, grooved ...	57.00	57.00
Skelp, sheared	60.00	60.00
Sheets, No. 28	73.00@ 75.00	90.00@100.00
Galvanized sheets..	105.00@110 00	125.00@140.00
Shapes	60.00@ 65.00	70.00@ 80.00
Plates	85.00@ 90.00	85.00@ 90.00
Hoops	65.00	65.00@ 67.50
Bands	58.00	70.00@ 75.00
Steel bars	58.00@ 65 00	60 00@ 65.00
Iron bars	58.00@ 60.00	65.00
Per lb. on large orders:		
Tin plate	6.50@ 7.00	7.00@ 8.00
Plain wire	2.90	2.95
Galvanized wire ..	3.50	3.65
Wire nails	2.85	3.00
Galvanized nails ..	3.85	4.00